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The Journal aims to publish material of interest to Agricultural Scientists, contributed by authors working in agricultural or related fields; authors need not be members of the Institute.

Contributions are of three types, namely: "Articles", "Technical Papers" and "Technical Notes". For information about the size and form of each type of contribution, see page 2 of the March, 1955, issue of the Journal.

Manuscripts should be double spaced and should be submitted in duplicate, as part of the delay in referring is then avoided.

For more detailed information concerning the preparation and lay-out of scientific papers, authors are referred to the C.S.I.R.O. publication "Guide to Authors" and to an article entitled "The Preparation and Editing of Technical Papers" by N. S. Noble, published in the Australian Library Journal, April, 1954. The policy laid down in these publications is also largely followed by this Journal.

In addition to the contributions described above, the Journal is pleased to publish "Letters", "News Items", "Talks" and "Personal Notes" which have been received from, or which are of interest to, members of the Institute.

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Reviews

THE NUTRITIONAL PHYSIOLOGY OF THE EWE IN LATE PREGNANCY

R. L. REID

Research at the Sheep Biology Laboratory in the fields of digestion, metabolism, endocrinology, and reproductive physiology is adding considerably to previous data from other laboratories in providing a sounder basis for an understanding of the problems associated with increased efficiency of reproduction in the ewe.

The theme which I propose to follow is that the nutrition of the pregnant ewe is of paramount importance in determining reproductive efficiency. No attempt has previously been made to integrate the results of diverse relevant studies in a single brief discussion. Without detailed presentation, adequate documentation is impossible, and hence the hypotheses and conclusions presented here cannot be entirely free of criticism. Discussion has been confined to energy requirements of the ewe and foetus, the aspect of pre-natal nutrition which appears to be of greatest importance.

Severe undernutrition in pregnant ewes increases losses of ewes from metabolic diseases such as pregnancy toxaemia and losses of weak lambs after birth; too high a plane of nutrition is wasteful and may increase losses of ewes at lambing and the number of stillborn lambs. Both extremes of nutrition should thus be avoided and maximum efficiency of feed utilization should be the aim, particularly as shortage of feed in late pregnancy is so often the rule in this country.

Assessment of Nutritional Requirements

The minimum amount of any feedstuff required by the ewe, at the several stages of pregnancy, to produce a lamb of sufficient body weight to ensure maximum survival and rate of subsequent growth is completely unknown; various feeding standards, so comprehensive for dairy and beef cattle, are notoriously reticent on the point. Various estimates of the feed requirements of pregnant ewes are available, but no experiments have shown, for example, how much extra feed is required by a ewe with twins, compared with one carrying a single lamb.

The rate of growth of the ovine foetus is more rapid than in most species investigated. It is twice as rapid as the human foetus. More than 75 per cent. of growth occurs in the last two months of pregnancy. It is now generally accepted that the plane of nutrition of the ewe in the first three months of pregnancy has no demonstrable effect on the health of the ewe or the lamb. However, numerous field and laboratory experiments have demonstrated the importance of level of nutrition in late pregnancy. Planes of nutrition have been

Dr. R. L. Reid is a principal research officer with the Division of Animal Health and Production, C.S.I.R.O., at the Sheep Biology Laboratory, Prospect, N.S.W. *This article is based on his Presidential Address to the N.S.W. Branch, presented on April* 11, 1958.

arbitrarily chosen, are often extreme and have usually been designated as high, moderate, or low, without reference, in field experiments at least, to actual feed intake. These terms have in most instances, been related to measurement of bodyweight changes. Maintenance of body weight is an effective criterion in nutritional studies on non-pregnant sheep; it is obviously an ineffective criterion in pregnant ewes. Birth weights of lambs from ewes which show a net loss in bodyweight during pregnancy may be the same as those of lambs from ewes which show a net increase in body weight (Verges 1939; Coop 1950; Papadopoulos and Robinson 1957), but more often are less (Thomson and Fraser 1939; Underwood, Shier and Cariss 1943; Wallace 1948; Thompson and Thomson 1949; Barnicoat, Logan and Grant 1949; Coop 1950). Some of the differences between results of different workers are obviously due to differences in the severity of undernutrition; others are more difficult to explain. The point of special interest is that undernourished ewes may produce lambs of normal birth weight. However, it must be remembered that twin lambs may be affected when single birth lambs are not (Verges 1939; Coop 1950). Conclusions drawn from birth weights of lambs from surviving ewes may be deceptive. Underwood and Shier (1942) found that a supplement of oats did not influence birth weights or subsequent growth rates of lambs born, but did significantly reduce losses from pregnancy toxaemia.

Studies on the physiology and biochemistry of the pregnant ewe are now providing criteria which may allow reasonable estimates of minimum feed requirements, particularly of ewes with twins. More important, these studies explain the peculiar susceptibility of the ewe to undernutrition, and have helped to elucidate the aetiology and pathogenesis of pregnancy toxaemia.

Effect of the Foetus

The full significance of the foetal demand for nutrients in late pregnancy can only be appreciated in the light of recent advances in our knowledge of digestion and metabolism in the ruminant.

The end-products of carbohydrate digestion in man are glucose or sugars convertible to glucose in the liver; the end-products of carbohydrate digestion in ruminants are the lower fatty acids—acetic, propionic and butyric. Yet the ruminant must have glucose—firstly to provide fuel for the central nervous system and secondly to facilitate the metabolism of acetic acid, which provides much of the body energy requirements. This requirement for glucose is met by an extremely efficient conversion of propionate to glucose in the liver; it can also presumably be met by conversion of absorbed amino-acids.

The high energy requirement of the foetus must be met by glucose. In the case of twin foetuses the requirement for glucose may represent a high proportion of the quantity available from propionate; in the undernourished ewe the proportion demanded is so high that supply no longer covers demand, and blood glucose falls. The foetus maintains a concentration gradient in its own favour by efficient placental synthesis of fructose from maternal glucose—total blood-sugar levels are some 40-50 mg per cent. higher in the foetus than in the ewe. Survival, but not necessarily maximum growth rate, of the developing foetus is thus ensured at the expense of maternal glucose.

If 30 per cent. of dietary energy is provided as propionate and is converted to glucose, and if the additional energy demand of twin foetuses in late pregnancy is 15 per cent. of the total maternal energy requirements, feed intake must be increased by some 50 per cent. if the additional demand is to be met. The actual increase will vary with stage of pregnancy, number of foetuses and the proportion of dietary energy available as glucose. There is evidence that the latter may vary widely. Some idea of the direction of these variations on different diets is beginning to emerge from studies of the chemical activities of the different bacterial populations present in the rumen on different diets (Balch and Rowland 1957; Reid, Hogan and Briggs 1957).

It is obvious that a maintenance diet for a pregnant ewe may be that amount of feed which will just prevent development of hypo-

glycaemia but standards based on feeding experiments and on total energy content of the diet take no account of this physiological basis.

Physical Limitations to Feed Intake

It is the inability of feed to supply sufficient glucose which necessitates high feed intakes by ewes in late pregnancy, particularly ewes with twins. In general, the lower the quality of roughage (using the term in its widest sense to include all pastures) the lower the appetite of the ewe. The term "unpalatable", as applied generally to low quality roughage, is a misnomer; recent studies by Weston (personal communication) at Prospect indicate that the *ad libitum* intakes of a variety of diets are the highest intakes of which the animal is capable, and that appetite may be largely controlled by rate of passage of digesta from the rumen. This, in turn, presumably depends on the rate of digestion and hence on the activity of the microbial population.

It is thus of interest that the large volume occupied by twin foetuses in the abdominal cavity in late pregnancy causes marked compression of the rumen. Blaxter (1957) has also drawn attention to the possible effects on rumen volume of the large amounts of fat present in the abdominal cavity of very fat ewes. We have observed that the *ad libitum* intake of roughage in late pregnancy by ewes carrying twins is less than that of ewes carrying single lambs, and Gordon and Tribe (1951) observed that the voluntary intake in the last month of pregnancy may fall by 20-40 per cent. in very fat twin-bearing ewes.

If reduction in rumen volume lowers appetite in late pregnancy, feed intake may fall below the level necessary to provide the glucose requirements of the ewe and foetus, particularly in very fat ewes carrying twins. This could explain the greater susceptibility of over-fat ewes to pregnancy toxaemia even when ample high quality feed is available to them. It would also explain why such ewes might produce light lambs, as is often claimed.

The Role of the Adrenals

The ewe underourished in late pregnancy becomes hypoglycaemic but there is a mechanism by which near-normal blood-glucose levels may be maintained if undernutrition is not too severe. The secretion of hydrocortisone by the adrenals, in response to hypoglycaemia, stimulates gluconeogenesis from body protein and blood-glucose levels are thereby maintained at the expense of maternal tissues. Net body-weight may decline but if sufficient glucose is produced for maximum rate of growth in the lamb, birth weights are normal. This would explain the observations of Verges (1939), Coop (1950) and Papadopoulos and Robinson (1957).

In severe undernutrition, adrenal hyperactivity fails to overcome hypoglycaemia. Continuing hypoglycaemia leads to reduction of foetal blood-sugar levels, maximum growth rate cannot be maintained and birth weights are reduced. However, foetal blood-sugar levels remain high enough to ensure survival in most instances.

Continued hypoglycaemia also sets in motion a train of metabolic consequences which often culminates in pregnancy toxaemia. The adrenals are hyperactive and enlarge; the metabolism of the ewe moves towards that characteristic of adrenal steroid diabetes. If undernutrition is severe and/or prolonged, ewes with twins succumb to pregnancy toxaemia. However, under usual field conditions, outbreaks of pregnancy toxaemia follow periods of severe physical or psychological stresses, such as inclement weather, disease, transport, or unfamiliar environment. The response of the adrenal cortex to stress is greatest if the adrenals have been primed by previous undernutrition, and is least in previously well-nourished ewes. Whether pregnancy toxaemia is precipitated by severe undernutrition alone or by environmental stress plus undernutrition, plasma hydrocortisone levels are increased significantly. Undernutrition, whether accompanying, or both preceding and accompanying environmental stress, is an indispensable predisposing factor (Reid 1958).

Until recently, is was considered that pregnancy toxaemia was essentially a sequel to undernutrition, but it is now clear that environmental stress is a critical factor. Indirect evidence from various experiments at

Prospect has suggested that the sheep is extremely sensitive to change in environment, and preliminary experiments in climate-controlled rooms have indicated that severe climatic stress due to cold, wind and rain evoke a profound adrenal response in undernourished pregnant ewes.

Neo-Natal Mortality

Physiological studies on newborn lambs from both undernourished and well nourished ewes are being carried out at Prospect by Alexander. Failure to suckle has proved to be a major cause of losses in newborn lambs. Light lambs from undernourished ewes have a relatively large surface area which contributes to a more rapid fall in body temperature after birth; loss of activity and of the sucking drive occur sooner. As in pregnancy toxaemia, climatic stresses are of critical importance, because wet and cold conditions hasten heat loss and the onset of weakness.

Wool Production in the Pregnant Ewe

A consideration of the factors influencing the efficiency of wool production in the pregnant ewe further emphasizes the key role of the adrenal cortex. Lindner and Ferguson (1956) have shown that adrenal steroid hormones inhibit wool growth; the effect can be produced by smearing an ointment containing 9 α-fluorohydrocortisone on localized areas of skin; the steroids thus presumably act directly upon the wool-producing follicles. When administered in excess these hormones can produce "tenderness" or "break" in wool, and the same effects are given by the adrenocortitrophic hormone (ACTH) of the pituitary gland, which normally initiates steroid secretion by the adrenal. "Break" in the field is associated with disease, undernutrition in advanced pregnancy, or environmental stresses which are known to stimulate ACTH secretion in other species.

Wool growth is reduced during pregnancy in well-nourished ewes; this is compatible with observations on adrenal hyperactivity during pregnancy in other species. The greater reduction which may be observed in ewes which produce lambs of normal birthweight in spite of a net loss of bodyweight during pregnancy (Papadopoulos and Robinson 1957) may be due to the extra adrenal hyperactivity presumably necessary to prevent severe hypoglycaemia. Severe undernourishment, with continued hypoglycaemia, may promote such intense adrenal activity that a partial or even complete wool "break" occurs. Complete wool "break" is a characteristic feature of pregnancy toxaemia.

Conclusion

Theoretically, ignoring overall economic considerations, maximum efficiency in reproduction (that is, maximum production of lambs per acre) will be obtained when the proportion of twin-bearing ewes is highest and the plane of nutrition during late pregnancy is the lowest compatible with normal birthweight of lambs and minimum post-natal losses. Wool production *per ewe* will be reduced; wool production *per acre* need not necessarily be lower. However, greater tenderness may considerably reduce the value of the fleeces from these "most efficient" ewes (Coop 1950).

In drawing attention to the paramount importance of nutrition in late pregnancy, I have assumed for purposes of discussion that lactation coincides with the period of maximum pasture growth and is not limiting. Under conditions where the proportion of twin-bearing ewes was high, this would usually be so. It can be mentioned, however, that studies by Alexander at Prospect have shown that undernutrition in late pregnancy may delay the onset of lactation; this may contribute to early post-natal losses of lambs, and depress total milk production.

The physiological considerations relevant to the peculiar susceptibility of the ewe to undernutrition in late pregnancy may be summarized as follows:

1. Very rapid growth of the foetus.
2. Placental synthesis of fructose from maternal glucose to maintain high foetal blood-sugar levels.
3. Limited supply of maternal glucose, and hence susceptibility to hypoglycaemia.
4. Reduction in rumen capacity, due to the large portion of the abdominal cavity taken up by the uterus and its contents.
5. Normally increased adrenal activity in pregnancy.

6. Priming effect of pregnancy and undernutrition (with its attendant hypoglycaemia) on the adrenals, leading to greater-than-normal response to environmental stress.

All these considerations lead inevitably to the conclusion that, in striving for maximum production, we are pushing our animals close to, or even beyond, their physiological limits, and are exposing many vulnerabilities. Among other things, research at Prospect is concerned with obtaining the basic understanding of physiological processes which will permit recognition of these limits and vulnerabilities.

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POSITIONS VACANT

PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the position set out hereunder will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including 12 January 1959.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

The appointee may be required to contribute to the Government Superannuation Fund.

First class fares for selected applicant and his family will be reimbursed; also half cost of transporting furniture and personal effects (provided the Government's share does not exceed £100): Provided that the appointee enters into an agreement to remain in the employ of the South Australian Government for at least two years.

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DUTIES: The appointee will be required to manage the College orchard and vineyard totalling 80 acres (6 irrigated) and to teach horticulture to Diploma students. The appointee will be expected to engage in investigation work dealing with the application of recent findings to field practice.

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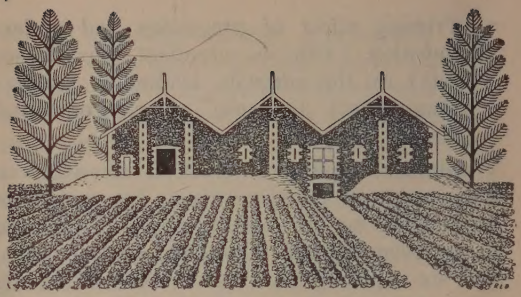

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It cannot be said therefore, that there is a lack of appreciation for a good claret in Australia, nor does a good claret escape recognition, as the following list of more recent tributes in the form of show awards testify:

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1954 VINTAGE - - - *1st Adelaide, 1955*
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WC120

LIGNIFICATION OF PLANTS IN RELATION TO RUMINANT NUTRITION

N. P. KEFFORD

As the result of successful research, principally in plant nutrition, improved pastures can now be grown in most areas of southern Australia, provided these have an adequate water supply. Thus in future pasture research the emphasis should shift to a consideration of the finer requirements of the grazing animals. At present, even on improved pasture growing under good natural conditions, these animals exist in an unsatisfactory and inefficient nutritional condition since they are subjected to alternate periods of feast and famine. Two worthy goals for research to aim at, are the general improvement of the nutritional value and acceptability of plant tissues, particularly mature tissues, and the spread of adequate feed supply over a greater part of each year than occurs at present. Some agrostologists believe that an advance towards these goals would be made if the lignification of plant tissues could be controlled.

Recently our knowledge of the biochemistry and morphology of lignification has advanced sufficiently to make it possible that a full review of the subject would achieve three objectives:

1. The assessment of the role of lignin in ruminant nutrition.
2. The definition of the gaps in our knowledge.
3. The indication of ways to fill these gaps.

These were the reasons for the organization of the symposium at Canberra last year, the proceedings of which are reviewed in this paper.

What is Lignin?

The Morphologists' Answer

Lignin, together with cellulose and non-cellulosic carbohydrates, is a constituent of the walls of some mature plant cells. In the walls of these cells, cellulose fibrils form a net-like structural framework, about which the other substances form an encrustation. In growth, the stretching of the cell wall requires relative movement between the cellulose fibrils and the ease of such movement will depend on the state of the encrusting substances. When first formed, the cell wall has only non-cellulosic carbohydrates as encrustants and given the right conditions these undergo the required plastic stretching. The introduction of the non-plastic lignin as an encrustant prevents wall stretching and hence cell growth. Limitation of growth, which involves the consequent determination of cell form, represents a possible morphogenetic function of lignification during the differentiation of plant cells.

Lignification of a cell commences at the corners, where debris of non-cellulosic carbohydrate from the cell walls of parent cells has collected following cell divisions. It is believed that this non-cellulosic carbohydrate may have a role in the initiation of lignification. From

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Dr. N. P. Kefford, a research officer of the Division of Plant Industry, C.S.I.R.O., Canberra, is Convenor of the Plant Physiology and Biochemistry Seminar Group, which conducted a symposium on "Lignification of Plants in Relation to Ruminant Nutrition", in Canberra, September, 1957.

This article is a review of the major viewpoints presented during the symposium.

The proceedings have been published in full and may be obtained by application to the Technical Secretary of the above Division.

the cell corners, lignification spreads along the walls and into the intercellular region. Within some mature cell walls, two layers, an outer primary and an inner secondary wall, can be differentiated. When cellulose is dissolved from sections of a lignified tissue, the lignin can be isolated from the primary wall and intercellular layer as an amorphous sheet, and from the secondary wall as a sponge like structure with many pores. Hence the lignin forms a dense membranous layer around the cell and penetrates between and encases the microfibrils, which are the biological units of cell wall cellulose. There is some evidence that lignin may even penetrate within the microfibril and interfere with the chemical reactivity of the crystalline cellulose. It is estimated that from 60 to 90 per cent. of the lignin is in the intercellular layer and 10 to 20 per cent. in the secondary wall.

That the progress of lignification changes the properties of the cell wall has been shown by its reactions to certain stains, which particularly reflect the physical state of the wall. These stain reactions showed that lignification prevented the dyes' penetration to and reaction with cellulose. Lignification would then appear to represent a gradual consolidation of the free space in the cell wall, a notion which is supported by the fact that unlignified walls shrink more on drying than lignified walls. Staining has also revealed that lignin is possibly linked to the non-cellulosic carbohydrate in the cell wall, an effect of particular interest to the present discussion.

The packing of lignin into the spaces in the wall between the cellulose microfibrils, allows it to perform what is probably its principal function in the plant. Whereas the cellulose fibrils oppose tension in the cell walls, the lignin packing resists compression. This property not only contributes to the rigidity of higher plants, but, as required by current theories of transpiration, permits conducting vessels to exist in a state of negative wall pressure without collapsing. Thus it is clear that the capacity to deposit lignin was a prerequisite to the evolution of vascular plants, particularly trees. Thus some lignification is necessary in the conducting tissues of a plant, and a lignin-free plant is unlikely to survive unless grown submerged in water.

The Chemists' Answer

Lignin is a polymer. Its building units are believed to be all related to the substance hydroxyphenylpropane (Figure 1), but the possibilities for variation on this basic structure are numerous. Linkage between the building units involves the phenolic hydroxyl group and the three carbon side chain, which are the essential substituents of the aromatic ring in the basic structure, but again there is much scope for variety in the actual linkages formed.

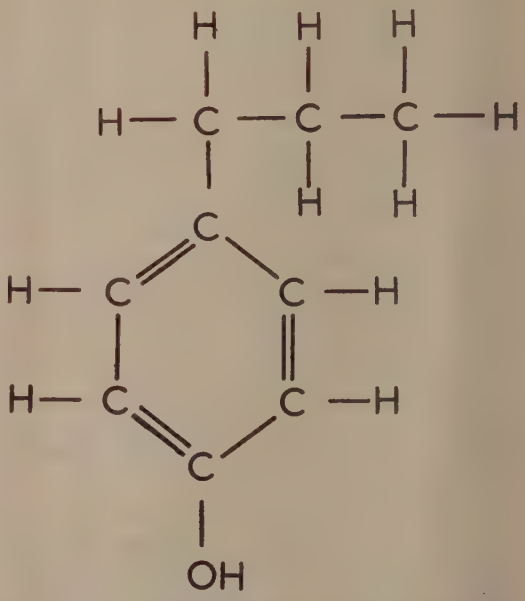

Figure 1—Hydroxyphenylpropane—the parent compound of lignin building units.

One lignin molecule can contain building units of differing detailed structure, and linked in different ways. Figure 2 shows a formula for lignin which illustrates the variety of possible linkages and building units, but it is not intended to portray the structure of a natural lignin. There is evidence that within one plant the composition of lignin can vary from tissue to tissue and with the age of the plant. Between species there are great differences in lignin composition. Thus the term lignin refers to a type of substance and certainly does not refer

to a compound of constant or regular chemical composition.

Lignin is difficult to isolate in its native state, and it is even more difficult to isolate native lignin quantitatively. This fact, coupled with the lack of a definite criterion for the purity of lignin, makes the analysis for lignin a real problem. The common method of assay, which measures the material insoluble in 72 per cent. sulphuric acid, separates the lignin as a highly polymerised non-reactive material, bearing little resemblance to the parent lignin. This method has been much criticized, but no practical alternative method has been suggested. It should be remembered, however, that this method was developed for the assay of woody tissues, and with tissues of herbaceous plants, containing appreciable amounts of protein, it is likely that some of this protein would be insoluble in 72 per cent. sulphuric acid along with lignin. Thus results obtained with this method of analysis must be treated with caution. It is also known that the degree of maceration of a material affects the lignin assay and this should be kept in mind when material is assayed for lignin before and after passage through an animal.

There is evidence that not all lignin occurs free in plants, part may be combined with carbohydrate, or with protein. But it appears that the nitrogen found in lignin of herbaceous plants does not form part of the basic aromatic ring structure of lignin. Obviously there is a great need for the investigation of the true nature of lignins from sources other than wood and for the development of a reliable method for the chemical assay of lignin in herbaceous tissues.

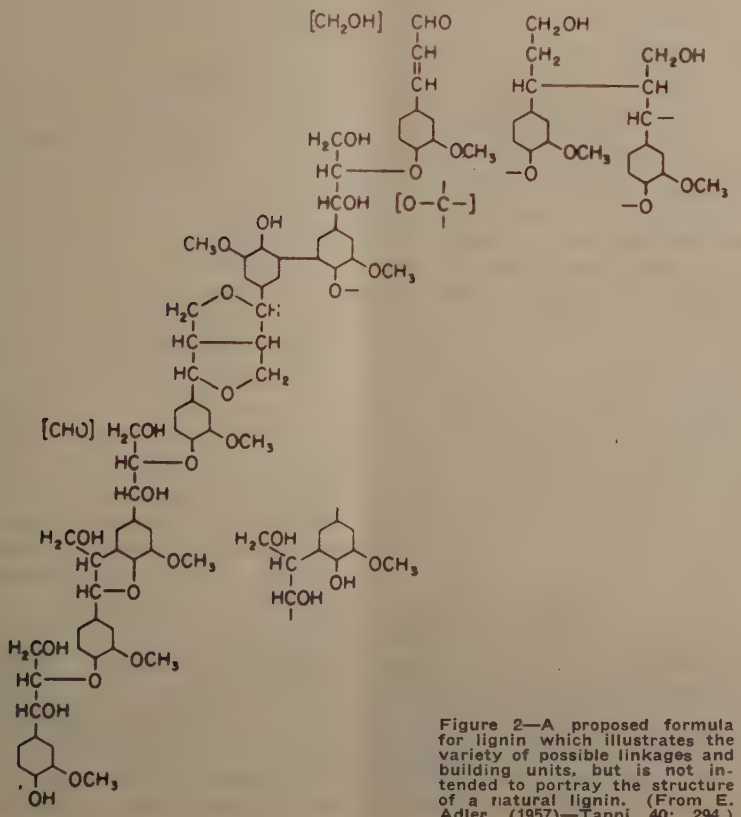

Figure 2—A proposed formula for lignin which illustrates the variety of possible linkages and building units, but is not intended to portray the structure of a natural lignin. (From E. Adler (1957)—Tappi 40: 294.)

Synthesis of Lignin in the Plant Cell

The polymerization of lignin building units requires an initial oxidation step, involving hydrogen peroxide and the enzyme peroxidase. The products of this oxidation then polymerize on a carbohydrate surface. The locations within the cell of these various steps in lignin formation are not definitely settled, but it is not unlikely that the building units are synthesised in the protoplasm of the lignifying cell and are oxidised by peroxidase located in the cell wall, then polymerization occurs on the carbohydrate surfaces of the wall.

The genesis of lignin is not entirely a function of the lignifying cell, there is evidence that it is under the influence of other parts of the plant through the agency of morphogenetic substances such as auxins. Auxins have been shown to induce the formation of the peroxidase which catalyses the oxidation of lignin precursors.

Decomposition of Lignin

The lignin polymers are chemically stable structures. The known differences in structure, which amount to differences in detail of structure of the building units rather than differences in the basic backbone of the molecule, are unlikely to affect this chemical stability. Very few bacteria have been found to attack lignin, and in all the confirmed cases these are aerobes. The decomposition of lignin is usually done by fungi, which, of course, are also aerobes. This suggests that lignin is unlikely to be extensively broken down under the anaerobic conditions of the digestive tract of the ruminant. There is direct evidence to support this notion, for chemically extracted lignin was found to be unchanged on passage through a ruminant or on treatment in an artificial rumen.

Little is known of the products of microbial breakdown of lignin. If, however, lignin were depolymerized during digestion by a ruminant, the phenolic products might be metabolised, if phenol decomposing bacteria occur in the rumen, or they may be detoxified and excreted as aromatic acids. In the latter case the animal would receive no nutritional benefit.

The possibility that the presence of lignin or of lignified tissue in the rumen inhibits bacterial growth directly, should also be considered. Experiments using cattle, sheep, or an artificial rumen, suggest that this is not so, because the addition of a lignin did not influence the digestion of cellulose not associated with the lignin.

It would thus appear that, from the point of view of ruminant nutrition, interest in lignin is indirect. Interest must centre not on the digestion of lignin, but on the effects of the presence of lignin on the digestion of other components of plant tissues. Thus the location of lignin relative to other components may be of greater interest than the gross amount of lignin occurring in a plant tissue.

Effects of Lignification upon the Utilization of Plants by Ruminants

The ruminant is adapted to derive energy from the digestion of cellulose. The insoluble nature of cellulose makes enzymic attack difficult and an attacking micro-organism must make intimate contact with a cellulose surface before the molecules can be broken down. Any factor which decreases the area of contact would retard breakdown and an encrustation of lignin on cellulose would certainly have this effect. By introducing the ruminant physiologists' concept *digestibility,* which gives the percentage of each crude component of a consumed feed that is available to the animal, it can be claimed that lignin would lower the digestibility of cellulose.

It is also possible that lignification may cause whole cells, or groups of cells, to remain intact in the rumen, when maceration is incomplete, and for their contents to be lost to digestion. This would lead to a lowering of the digestibility of feed components other than cellulose. At this point it could be mentioned that cutin, an encrusting wax occurring around most external cells of plants, might similarly hold cells, or groups of cells, intact in the rumen.

The concept of digestibility cannot completely describe the effects of lignification on the utilization of a feed by a ruminant and the concept of *appetite* must be considered.

The appetite of a ruminant is principally a function of the amount of material already in the rumen and can be measured by the inverse half-life of food material in the rumen. To leave the rumen, plant tissue must be reduced to a size that will pass through the minute reticulo-omasal orifice. Lignification of the plant tissue would make reduction in size more difficult, its half-life in the rumen would increase and appetite would fall. Now, bacteria continuously pass out of the rumen whether plant material is doing so or not. The bacterial population in the rumen must be maintained by growth on nutrients, principally of plant origin. By making such nutrients less available, lignification of plant tissues could delay the build up of the bacterial population and would further increase the half-life of material in the rumen.

A third concept of interest is the *efficiency of conversion* of plant components into animal components. Lignin could reduce the efficiency of conversion of plant nitrogen into animal nitrogen by its combination with non-cellulosic carbohydrates. These substances are considered to determine in part the efficiency of nitrogen utilization by the ruminant, because those rumen bacteria which metabolise them can multiply quickly and mop up excess nitrogenous compounds, which otherwise would pass out of the rumen, be converted to urea, and then be lost in part by secretion.

Some direct evidence is available to support the above claims of probable effects of lignification on the nutritive value of plants to a ruminant. For example, live weight gains of steers have been shown to follow closely changes in the lignin content of grasses throughout a season, and a close relationship between organic matter digestibility, in cattle and sheep, and lignin content of some feeds has been established.

Work on Canadian pastures has yielded significant results. On maturation, some Canadian native grasses were considered to maintain their nutritive value, whereas the nutritive value of introduced grasses fell away quickly. In the native grasses, lignin was restricted to conductive tissues, whereas, in the introduced grasses, it spread to neighbouring, parenchymatous, storage tissues. These results suggest that the location of lignin may be as important as the gross amount present, in determining nutritive value of a plant.

Without doubt, the principle that liginfication of plant tissues reduces their nutritive value for the ruminant has been established. There is equally no doubt that lignin is not the only, nor the limiting, factor influencing nutritive value in all situations.

The situations of particular interest to many participants in the Canberra symposium have been those involving mature pasture. It is claimed that nitrogen is the dominating factor in the low nutritive value of pastures in the extremes of maturity, such as wheaten straw and mature tropical grasses. The plant material termed mature by the agrostologist is, in physiological terms, senescent or dead. The processes involved in senescence have been well studied, particularly in leaves. It is known that leaves accumulate nitrogenous compounds during growth, but nitrogen may soon begin to be lost from the leaf. This is not due to the loss of the capacity to synthesise protein, but is attributable to a greater demand for nitrogen by the younger growing parts. The degree and rate of nitrogen export depends on the plant's nutritional status with respect to nitrogen and other elements, on the phase of development of the plant—fruit and seed formation usually greatly accelerating the drain from all leaves—and on the particular plant involved.

Depending again on conditions, the picture given for nitrogen in a senescent leaf, is repeated for other constituents. For the present argument, the soluble and readily hydrolysable carbohydrates are probably the most important.

Thus, in a senescent plant, lack of available nitrogen and non-cellulosic carbohydrate, and increases in degree of lignification and in the proportion of highly lignified tissue, may act synergistically in diminishing the value of the plant to a ruminant. In a particular situation, one of these might be the dominant factor, but alleviation of any would lessen the adverse effects of the others.

Investigation and Control of Lignification in Plants

The discussions at the Canberra symposium made clear the need for anatomical studies on pasture plants, in order to follow changes in the location and degree of lignification in plants at all stages of growth and development. Only the simplest of techniques for sectioning and staining would be necessary for the degree of lignification of each tissue to be determined. From the proportions of each tissue in the plant the degree of lignification of the whole plant could be estimated. Such estimates, made on pasture plants during the ageing and development processes, would greatly assist in the assessment of the importance of each of these growth phases in the lignification of the plant, and the assessment of the possible effects of this lignification on the nutritive value of the plant to the ruminant. In many species, ageing and flowering can be studied separately by maintaining plants under the appropriate lighting conditions.

Little precise information is available on the physiological factors which control lignification, and these obviously need investigation. It is generally considered that lignification increases with maturation, flowering, and physiological stress; light intensity is also thought to be a factor. The effect of these factors and of changes occurring in the field could be readily studied using the simplest morphological techniques. The study of physiological factors affecting lignification would suggest means of control, and there is also the possibility of chemical control, perhaps indirectly by controlling plant development.

Not all tissues are lignified to the same extent; stem tissues generally show greater lignification than leaf tissues. If the proportion of the various tissues comprising a plant change, as occurs during development and particularly at flowering, then the degree of lignification of the whole plant must change. Hence, the gross amount and location of lignin in any tissue, and the ratios of the various tissues forming the whole plant must be considered. In grasses, and to a lesser extent in dicotyledons, a sharp rise has been found in lignin content at the inception of flowering. This might be expected from the growth of flower stalks and heads. If flower initiation could be shown to be one of the most potent influences on lignification in grasses, the development of late or non-flowering strains of perennials, a quite feasible objective, might yield pastures of considerably improved nutritive value.

The steps, in the biosynthesis of lignin, of oxidation of the building units and polymerization of the oxidation products have been described. In addition to these steps there are the pathways of synthesis of the building units and hydrogen peroxide and mechanisms for the induction of peroxidase, the production of peroxidase activators, the synthesis of auxin and the transport of auxin. Since, theoretically, each step provides one opportunity for the control of lignification, it would appear likely that different clones of a plant species should vary in the amount and location of lignin and thus provide the necessary basis for the breeding of plants of reduced lignin content. In fact it has been shown that leaves of a number of clones of the grass *Agropyron intermedium* differed considerably in lignin content. A plant with reduced overall lignin content would be achieved by breeding for a reduced fraction of highly lignified tissues. But the tailoring of the ideal fodder plant may be best approached through the control of the general maturation process in plants.

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FACTORS INFLUENCING POST-WAR LAND DEVELOPMENT IN WESTERN AUSTRALIA

G. K. BARON-HAY

I propose to deal with the subject by relating briefly pre-war and post-war conditions in land development, in an attempt to indicate the great changes in the pattern of agricultural usage of land—and hence production—since the last war, using Western Australia as an example.

After the 1914-1918 war, and in an intensified degree after the last war, the problem of rehabilitating large numbers of men and women into useful civilian occupations weighed heavily with Governments. Traditionally, as might be expected in a comparatively young country (developmentally) like Australia, thoughts turned to the prospects of land development. There was a real fear of unemployment immediately following the war, so much so that the Government of the day in 1943—two years before the European war concluded—appointed a Commission to report and advise on all aspects of Post-War Rural Reconstruction. I have no doubt that the findings and recommendations of this Commission—based almost entirely on previous experience in land development—strongly influenced the conditions of the War Service Land Settlement Scheme.

Prior to the first war, land development—whether by private enterprise or by Government sponsored schemes—had been confined almost entirely to land suitable for growing cereals, particularly wheat. This land—being in areas of comparatively low rainfall—had certain important advantages, which made possible successful development by men with little capital or experience in agriculture but with unbounded determination.

The advantages of such districts were that:—

1. Areas were comparatively sparsely timbered.
2. The timber burnt readily shortly after being felled, including the roots to below ground level.
3. Cropping could be undertaken with wheat the first year.
4. The crop was readily saleable, and was expected to pay the cost of clearing, including the keep of the settler.
5. No fencing was required for stock.
6. Traction power was from horses which were fed off the farm.

Any land which was not attractive for cereal-growing remained undeveloped, so that in Western Australia—where a feature of the soils is their extreme variability—considerable areas of intractable, infertile, usually sandy soil remained undeveloped, interspersed amongst and surrounded by areas developed for cereal-growing. Some of these undeveloped

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areas were extensive, lying in bands up to 20 or 25 miles wide. This increased the cost, or the earning, of public utilities, such as roads, railways, telephone, and water facilities.

Post War I Settlement

This, then, was the picture up to the end of the first war in 1918.

In 1920-21, owing to depressed conditions in Great Britain, a scheme sponsored and financed by the British, Commonwealth and State Governments was proposed and accepted by Western Austraila to establish migrants on virgin land. Land considered suitable for cereal-growing at that time was not available, and for the first time virgin land in the heavy rainfall and forested areas of the State—which was costly and difficult to clear and on which it would take several years to establish pasture before any revenue could be expected —was developed under a Government financed scheme.

These heavily timbered areas were destined to present soil, plant, and animal deficiency difficulties, the solutions of which were an important contribution to the understanding of trace element deficiencies in animal and plant nutrition in Australia. I think it can be said that Western Australia has, with the possible exception of iodine, all the known trace element deficiencies.

It is worth noticing that before the last war preference was given to migrants with rural experience, or those wishing to take up farming. There was, however, little immigration after 1929 owing to world-wide depression. The next 10 years being a period of recovery and consolidation of existing developed areas.

During these years, as a result of demonstrations on farms, experimental work on Research Stations, and by the then C.S.I.R., the great value of phosphates on pasture, particularly those including subterranean clover, was being recognised in the wetter areas but had not yet received general application in the wheat and sheep areas with annual rainfalls from 16 to 20 inches.

The advantage of introducing subterranean clover into the cropping rotation, and spreading the time between crops had been pointed out by *Dunn and Shier (1934) and others but had not yet received great attention.

The emphasis in any land development that was taking place at the outbreak of war in 1939 was upon areas suitable for wheat and coarse grain production.

Post War II Settlement

It was inevitable that there would be a great stimulus in land development on the cessation of hostilities in 1945, though—because of a lack of materials and the unexpected shortage of manpower—results of developmental work did not become evident until after 1947.

There was, too, immediately following the war, a feeling of uncertainty regarding the future markets for agricultural produce.

The war ended with the world down to bare boards for most basic foodstuffs; and the effective advocacy of the Food and Agriculture Organisation of the United Nations Organisation for raising the standard of nutrition for two-thirds of the world's population to a healthy level—together with the provision of finance, principally by the United States, to enable war affected countries to purchase foodstuffs—did much to create a feeling of security for increasing production.

Confidence in the future of agricultural production, however, was fostered also by factors within Australia, namely—

- The announcement by the Commonwealth and State Governments of a generous scheme for soldier settlement.
- Liberalisation of tax deductions after June 30, 1951; designed to stimulate primary production, particularly on certain structures and new machinery.
- The experience gained during the war in the use of heavy tractors and dozers for the knocking down and subsequent stacking of heavy timber for clearing.
- The continuation of war-time marketing agreements at profitable prices for major agri-

cultural products, which tended to still the fear of gluts or over-production in farmers who had experienced the depression years of the thirties.

- An active and most successful immigration scheme for people skilled in trades rather than in rural activities and who therefore were consumers rather than competitors in primary production.
- The necessity of creating overseas credits, which could be quickly achieved by the export of primary products.
- A growing technical knowledge about soil deficiencies and control of disease both in plants and animals.

These factors all created a stimulus not only for soldier settlement but for land development by private enterprise by increased clearing on existing holdings, as well as the development of new areas by those with money to invest.

During the war, because of the important role Australia played in the supply of foodstuffs to the armed forces and to Great Britain, there seemed to be a complete change of outlook by the public generally towards agriculture, and this was nowhere more markedly shown than in the conditions considered necessary to ensure soldier settlement on a sound economic and social basis.

The Rural Reconstruction Commission (1945*b*) had recommended that new lands should be developed only when needs cannot be economically met by the intensive use of settled areas.

An attempt was made to follow this policy in all States at the commencement of the Scheme for two main reasons:—

1. Price control continued for approximately four years after the war, which enabled estates to be bought at values related to productive capacity at the then controlled prices of products.
2. As the Rural Reconstruction Commission (1945*a*) emphasised strongly the "suitable Crown Lands in the various States are limited in number", presumably having in mind land of the type already in production and having a reliable and sufficient rainfall.

However, it was abundantly clear quite early that—by adhering to this policy in the absence of compulsory acquisition—only a small portion of soldier applicants could be provided with farms.

In Western Australia estates to the value of £3,518,000 were purchased. Nearly all of these were only partly developed and were suitable for sub-division.

The possibility of purchasing estates became difficult after 1949, when the regulations controlling the maximum prices at which land could be sold were repealed, and economically quite impossible after 1950, when the prices for our two staple commodities wheat and wool rose to previously unknown levels.

If soldier settlement was to continue, new lands therefore had to be found. This necessitated completely new ideas regarding types of land suitable for economical development.

Farmers and technical agriculturists turned their eyes to the possible development of light lands suitable primarily for grazing.

For some ten years before the war data had been accumulating in Western Australia —particularly at the Wongan Hills Light Lands Research Station—covering the management of light lands. This evidence proved the possibility of growing early strains of subterranean clover, and its effect in raising the sheep-carrying capacity of a farm in the 14 to 20 inch rainfall; and also—equally important—the possibility of growing a profitable cereal crop after some years lying in pasture.

"Ley farming" in cereal-growing areas had been demonstrated, and was to extend rapidly through the State.

Although there had been a hiatus in research work during the war, sufficient evidence had been collated by 1940 to show that trace elements, particularly copper and zinc, were a limiting factor in agricultural production on our light lands.

Work on these aspects was intensified after the war, but development of the many millions of acres of light lands in Western Australia proceeded ahead of precise knowledge as to cultural requirements in each district. Farmers and settlement authorities played safe by applying both copper and zinc on all light soils, though subsequently sometimes one or other was found to be unnecessary.

The most interesting technical feature of the post-war period is firstly the recognition by research workers—and then the rapid correction by the practical agriculturist—of trace element deficiencies. On the basis of quantities of trace element containing fertilisers sold, it is estimated that from five to six million acres—i.e. a quarter of the cleared land in the State—has received an application of trace elements, usually copper and zinc, although there is some call for molybdenum, manganese, and cobalt.

It might be said that the commencement of settlement should have been delayed until detailed soil analyses had been obtained, experiments in the field carried out, and until economic data regarding production of crops was available.

It is agreed that this detailed information is desirable but not necessarily essential, provided the general principles of land treatment in the particular environment are understood.

An example might make my meaning more clear. In examining the use of irrigation in the Northern Kimberley areas of Western Australia, it was approached as a valuable adjunct to the pastoral Industry—already well established. Irrigation was thought of as a means of providing urgently needed green pasturage during the dry winter months. In practice, so far, this usage has proved most disappointing, but work at the Kimberley Research Station has shown that the success of irrigation will be from crops such as sugar cane, rice and perhaps, cotton and sorghum. Research was necessary to ascertain, firstly, the general principles of land usage in that area.

In the case of light land utilisation, a few widely separated experiments had indicated the need for copper and zinc, together with phosphates, for successful pasture or crop production. Little was known about the best rate of dressing, or how frequently applications should be made. Time alone would determine these aspects. In this instance, a risk may be justified in developing light land on general methods, although, as knowledge accumulates, the details of developmental techniques may vary from district to district.

The securing of such precise data may take some years; and, even now, thirteen years after the end of the war, sufficient trained staff is not available for such work.

The initiation of Land Settlement projects —whether by private enterprise or Governments—is governed by many influences outside those of an essentially agricultural nature. However, the precaution always can be taken to initiate cultural experiments in any new area where prior research work has not been carried out. These experiments can proceed along with the more extensive developmental work, as planting of the main area on these soils does not take place for at least two years —and settlement for three or four years— after clearing.

I feel that if the first areas of the light lands along the Southern Coast had not been developed with vigour by the State, and supported by the Commonwealth ten years ago, there would not have been such a keen public demand for land in these areas today.

I mentioned the War Service Land Settlement Scheme as being a stimulus to the production of light lands initially for grazing in Western Australia, and I would like to put this aspect in its right perspective.

The new areas developed for soldier settlement in W.A. amount to approximately half-a-million acres, but this is only about 10 per cent. of the total area cleared during the last ten years by existing landholders or by new settlers who were able to finance the development of light country.

Each year, during the last ten years, approximately half-a-million acres of new land has been cleared in Western Australia, though the

indications are that this may slow down—as most of the older farms are now fully cleared, and, because finance from profits is becoming more difficult to obtain. The majority of the areas that have been cleared are known to be light lands, although separate statistical records have not been kept on this point.

Patterns of Land Use

The most obvious change in land use in the agricultural districts in recent years is the steadily rising importance of grazing as compared with other farm activities. Some indication of the magnitude of this change can be gained from land use statistics, see Figure 1. For example, in 1939 the 7.5 million acres classified under the headings of artificially sown pasture (1.1 million) and volunteer pasture* (6.4 million) constituted 51 per cent. of the 14.6 million acres of cleared land. In 1956 the 6.1 million acres of artificially established pasture and 8.6 million acres of volunteer pasture was 66 per cent. of the total cleared area of 22.2 million acres. The combined area of crop and fallow was 7.1 million acres in 1939 and 7.5 million acres in 1956. The cropped area has increased during that period, but there was a corresponding falling off in the amount of fallow. In the western and parts of the central wheat belt, where subterranean clover flourishes, ley farming has practically superseded the crop-fallow rotation, though fallow still maintains its importance in the drier parts of the wheat belt where subterranean clover does not grow. This is clearly shown in Table 1 by taking four sample districts across the grain-growing areas from West to East—that is from higher to lower annual rainfalls.

In the Williams district on the south-western fringe of the wheat-growing districts, with a rainfall of 21½ inches, the ratio of cropped area to area of bare fallow was 2:1 in 1935 and 18:1 in 1955. In Quairading with 15¼ inches rainfall in the central wheat belt it was 1.2:1 in 1935 and 3:1 in 1955. In Mukinbudin with 10¼ inches in the north-east, it was 2:1 in 1935 and 2.5:1 in 1955.

In the Avon Valley in the western edge of the wheat belt, fallow constituted nearly 20

TABLE 1.

Ratio of Crop to Fallow.

District	R'fall	Acre crop/acres fallow 1935	1955
Williams	21"	2	18
*Avon Valley	18"	1.6	7
Quairading	15.25"	1.2	3
Mukinbudin	10.25"	2.0	2.5

*Estimated from survey material under examination.

*"Volunteer" means herbage growing after a crop. Practically no natural pasture occurs in the Agricultural areas of W.A.

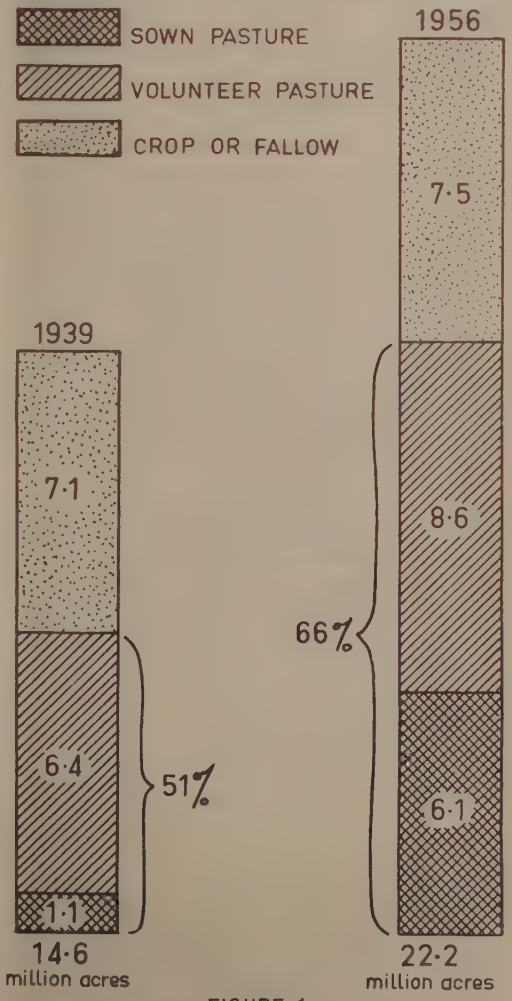

FIGURE 1
Acreage of pasture and crop in Western Australia in 1939 and 1956.

per cent. of the cleared land in 1939 but less than 3 per cent. in 1955.

Throughout these areas, particularly in the western part, sheep-raising has become the dominant activity on most farms with wheat-growing as the secondary activity. Production of coarse grains has increased, particularly oats, which is the chief supplementary fodder for sheep.

Most of the post-war development of new land has ocurred in regions with less than 25 inches annual rainfall and is used primarily for wool production. However, much of it is also very well suited for meat production, and changes in the relative profitability of wool and meat could bring about a marked expansion of meat production.

The swing to grazing occurred also in the heavier rainfall districts of the south-west, though on account of smaller holdings there was less scope for it there than in the wheat belt. Wherever possible farmers in the south west have endeavoured to increase grazing activities with cattle and even sheep.

The extension of subterranean clover or other legumes into the drier areas in the lighter soil types not only increases stock-carrying capacity but also greatly improves crop yields.

At the Wongan Hills Agricultural Research Station, the average yields from 22 crops of wheat grown before clover was introduced was 14.2 bushels. The same paddocks after growing clover from two to seven years yielded 22 bushels, an increase of over 50 per cent. In districts that may be marginal at present owing to low rainfall, the average increased yield would be less than 50 per cent.

An important direct result of the bringing into production of light land under a ley farming system is the raising of the potential of the State for cereal production, including wheat.

A five year rotation could result in at least 2 million more acres of cereals being planted annually, which could be wheat, oats or barley according to the market demand. This reserve for cheap cereal production could be of Australian significance if a quick step up in wheat production should be required.

The combination of subterranean clover, trace elements, and heavy dressings of superphosphate has transformed the prospects for several million acres of the so-called "sandplain country" of Western Australia. A great deal has been accomplished in the past ten years, and, provided economic prospects—particularly for wool—remain favourable, new development will continue for some years, particularly around the western and southern coasts.

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POST-WAR DEVELOPMENT OF PASTURES AND HORTICULTURAL CROPS UNDER IRRIGATION IN VICTORIA

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The Soldier Settlement Commission in Victoria has settled almost 6,000 ex-servicemen on the land since World War II. About half of these settlers have been financed to buy existing farms, some 600 of which were in irrigation areas. The other half have been settled on new projects, roughly in the proportion of two-thirds on dry farms and a third on irrigation farms. Thus there are almost a thousand settlers on new irrigation projects, the planned development of which is the subject of this paper.

The projects now completed and in operation include 640 dairy farms, 246 vineyards for the production of dried fruits and 67 orchards producing canning fruits. These projects have been eminently successful and only 5 per cent. of original settlers have relinquished their holding from all causes. Investigations have shown that these causes are generally associated with the individual rather than the project, and such a proportion would be expected in any human sample, however well selected.

The factors contributing to this successful settlement are rigid selection of settlers, liberal conditions of settlement and thorough planning of projects.

Selection of Settlers

Settlers were selected on the basis of their knowledge and experience of the type of production to be followed, and on personal characteristics. They were listed in order of suitability and allotted farms in that order. There was no balloting.

Conditions of Settlement

During the early development period, prospective settlers were employed on the projects, so that by the time the holdings were ready for the settler to enter into occupation, in many cases they were familiar with the project and even with the individual farm they selected. They were then assisted to develop the property, and finally will be given a "purchase lease". The period of time between first occupation and this purchase lease varies with the type of farm; on dairy farms it is usually five to six years, on vineyards six to seven years and on orchards eight to nine years. The liability assessed against the property for the purchase lease is not necessarily the full cost of development, and the settler is then given 55 years to repay this liability assessment with interest at two per cent. per annum, and the right to repay in full at any time. Nearly half the settlers are now in this purchase lease stage.

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The decisions arrived at for size of holdings for the various types of production were based on knowledge of soils and climate, and the result of previous experience in closer settlement. Over the years, farm sizes from earlier projects had changed to a limited extent by subdivision or amalgamation, until in many cases a median farm size had emerged. The farm size used in post war settlement was in all types of production greater than this median.

Farm size was also related to water right allocations which had to vary with the type of production. In the Robinvale dried fruit area the holdings have about 20 acres of land suitable for irrigation, with a water right of 50 acre feet. In the Murray Valley Irrigation District, north of Shepparton, the canning fruit properties have a minimum of 40 acres of suitable land, again with a water right of 50 acre feet but with an additional "sales quota" of 30 per cent. of water right which will be available in most years. The dairying properties in this district have approximately 100 acres of suitable land, and a water right of 100 acre feet. Again there is a sales quota of 30 per cent. of water right. In fact, sales of water in excess of water right have been available every year so far, and have generally exceeded 30 per cent. Two other projects, in the Central Gippsland Irrigation District and also a smaller one near Horsham in the Wimmera, are also devoted to dairying. These farms are on a similar basis except that the area is 80 rather than 100 acres, with a proportionate water right adjustment.

Planning

Before selection of any area for development, a preliminary assessment was made of facilities such as transport, water and power supply and amenities. Topographical and soil reconnaissance surveys were carried out, often of several alternative areas.

When these areas had been selected and the land purchased, the next stage of detailed surveys was undertaken. The earliest survey, that of the Murray Valley Irrigation District, was carried out by C.S.I.R.O., but all subsequent surveys have been the responsibility of the Victorian Department of Agriculture. These were at least "Stage 3" surveys, and included, where necessary, special investigations of soil salinity, infiltration characteristics and permeability for drainage.

The State Rivers and Water Supply Commission undertook all detailed contour surveys necessary for the design of irrigation supply, land preparation, and provision of drainage for the project. Detailed district plans were prepared showing this information, and the land was then subdivided according to the principles already laid down. In consultation with the Soldier Settlement Commission, plans of each holding were prepared; these showed the complete layout including location of house and farm buildings, laneways, fencing and areas devoted to specific crops.

Implementation

The Water Commission undertook all construction works associated with water supply, both for the project and on individual holdings. The latter involved land grading, and on dairying properties the sowing of 60 acres of lucerne and permanent pasture. The property was generally handed back to the Soldier Settlement Commission after the first successful irrigation. The Soldier Settlement Commission undertook the erection of houses, buildings and fences, domestic water supplies such as bores and tanks, and on horticultural properties the planting of vineyards and orchards.

Provision for drainage is being made in all cases. It was considered preferable to concentrate in the first instance on development for production, and to follow this with construction of drainage outfalls. These have now been completed or are proceeding in all four projects. In Robinvale, sealed pipe main drains are being provided so that each holding will have an outfall at a minimum depth of four feet at the lowest corner of the holding. Settlers are being assisted with the design and installation of tile drains to discharge to these outfalls. In all other projects, surface drainage is being provided, so that eventually every holding will have access to an outfall.

The settler enters into occupation when the farm is developed to the stage where he can manage it single-handed. Subsequent development and all financial matters are supervised by the Soldier Settlement Commission.

Through all stages, each project had a consultative committee, with representation from the two Commissions and the Department of Agriculture. These committees were available for advice on policy, and also dealt with specific problems as they arose, thus greatly assisting in co-ordination of the multitude of operations necessary in irrigation land settlement.

Conclusion

The success of post-war land settlement under irrigation in Victoria is demonstrated by the very low proportion of original settlers who have relinquished their holdings. It is suggested that a certain number of such cases is inevitable in any scheme involving large numbers of men, no matter how those men have been selected.

The main factors contributing to successful settlement are rigid selection of settlers, accompanied by terms of settlement aimed at eventual freehold ownership. Another factor assisting in this result has been the thorough investigation and planning of all the projects undertaken.

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THE ROLE OF THERAPY IN THE CONTROL OF PLANT DISEASES

I. D. GEARD

A number of therapeutic treatments for control of plant diseases have been worked out but very few have been developed to the level where they are in general use. Although there will always be particular circumstances in which they can play a very important part in plant disease control it is unlikely that such treatments will ever be widely used.

With the majority of plant diseases the often repeated platitude, that prevention is better than cure, is quite true and the work and advice of plant pathologists are mainly directed towards control through prevention of disease. The reasons for this may be divided into two groups. Firstly there are those depending on economic and practical considerations and secondly those concerned with the inherent difficulties of therapy in plants.

Economic and Practical Limitations

The first economic consideration is that, with a few obvious exceptions, plants are individually less valuable than animals, and the sacrifice of a few for the benefit of the remainder is not regarded as a serious matter. Even an apricot tree, despite its size and apparently high productive value is, in Australian orchards, worth only something of the order of ten pounds and if it is severely affected with a systemic type of disease such as black heart (*Verticillium*) it is better to remove and burn it rather than leave it to endanger other healthy trees while a cure is attempted.

When one is concerned with plants such as pine trees, which may be worth fifty to sixty pounds if suitable for plywood, or with large ornamental trees such as oaks which, if healthy, would have fifty or sixty years of life before them, the plant pathologist must give serious thought to the possibility of a cure and not offer too hastily the classical advice to "dig it up (or chop it down), and burn it".

Apart from the fact that individually plants are usually less valuable than animals there is a further indefinable factor; one sick animal, despite its relatively low value in monetary terms is often the cause of far greater concern to a farmer than a valuable crop—say a wheat crop—threatened by disease. The different rates of spread of diseases may be important in conditioning this attitude. Animal diseases, once they become established tend to spread rapidly whereas the spread of plant diseases is generally slow and unspectacular. It may be significant that the plant diseases such as Irish Blight (*Phytophthora infestans*) and Vine Downy Mildew (*Plasmopara viticola*) which sometimes spread very rapidly, (in the words of the farmer "they come overnight") are held in as much awe as the epidemic diseases of animals.

A natural result of the more complacent attitude towards plant diseases is the lower social and economic status of workers in the plant sciences. This is reflected in the smaller amounts of money granted by governments and philanthrophic institutions for research in plant sciences than for research in medical and

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veterinary fields. For this reason much less is known about fundamental problems not only in plant pathology but also in plant physiology and biochemistry. For instance the hormones governing the process of reproduction in animals are well known, but plant physiologists still differ as to whether flower induction follows the production of a florigen or the destruction of a colysanthin (Barber 1958).

Inherent Difficulties in Plant Disease Therapy

The inherent difficulty of isolation in plants is in practice another factor which makes prevention rather than cure even more desirable than it is in animals. An animal suffering from an infectious disease can be isolated quite easily so that it does not endanger the rest of the flock or herd. Moving an infected plant would in most cases serve merely to hasten its end so that once removed it is best burnt.

Two further reasons for the greater difficulty of therapy in plants, as compared with animals lie in major differences in physiology. Plants lack the highly developed, continuous circulatory system which is present in animals and they possess no antigen-antibody mechanism whereby they can cure themselves.

In animals one has only to introduce a therapeutant into the circulatory system and its passage throughout the entire body is virtually assured. In plants there is no such assurance and the effective distribution of therapeutic agents is a problem of considerable importance.

The absence of any antigen-antibody mechanism means that there is no possibility of inducing in the plant the production of substances specifically antagonistic to a particular pathogen. There is evidence that a number of plants produce toxins (Spencer, Topps and Wain 1957) or phytoalexins (Müller and Börger 1941; Müller and Behr 1949), but these are non-specific in their activity and are produced in response to a general, not a specific, stimulus. There are also a number of defence reactions involving the erection of physical barriers to the progress of infection but considerably more will need to be known about the mechanism of their induction, before there is much chance of their being used for therapeutic purposes.

Another mechanism which is superficially reminiscent of the antigen-antibody system is that which enables one to protect a plant from infection with a severe strain of virus by previously infecting it with a mild strain of the same virus. This however requires the continued existence of mild virus in the host and is thought to depend for its effectiveness on a saturation of specific active sites or groups essential in the process of virus multiplication and certainly not on the production of antibodies.

Therapy in animals is made relatively easier in most diseases by the wider divergence between the fundamental physiologies of host and pathogen. The majority of animal diseases are due to bacteria which are regarded as plants but in plant diseases—both fungus and bacterial—the pathogen and host are much more closely related and therapy is consequently more difficult.

The foregoing discussion is concerned with the reasons why the plant pathologist is more concerned with prevention than with cure. Protective sprays, seed treatment, soil sterilisation, crop rotation, certification schemes and the use of resistant varieties are all directed towards this end. There are nevertheless, circumstances in which it is practicable and economically sound or desirable to cure diseases of plants. Such circumstances arise when the individual plants are of high economic or aesthetic value, when a particular horticultural or agronomic variety is universally infected with disease and a nucleus of healthy stock is required for propagation or simply when normal methods of protection are inadequate or uneconomic.

The destruction by the use of hot water or chemical treatments of pathogens carried over in the internal tissues of seeds may perhaps be regarded as examples of successful therapy. However since the pathogen is not in an active state and no departure from normal function or morphology is usually involved, the seed is not strictly diseased although the plant which develops from it may be.

Heat Therapy of Virus Infected Plants

The greatest success in the field of plant disease therapy has been the development of methods of obtaining healthy plants from virus infected stocks. One of the most important of these methods is heat treatment. It has been found that, with some viruses in some hosts, if the infected plant is maintained at a high temperature for a certain length of time the virus is destroyed but no permanent damage is done to the host.

One of the first to use heat treatment successfully for the elimination of virus diseases was Kunkel. In 1936 he showed that healthy bud material could be produced from peach trees infected with peach yellows, simply by immersing the bud sticks in water at 56°C for periods even as short as 15 seconds (Kunkel 1936). Similarly budwood can be cured of rosette virus by treating at 50°C for 4 minutes and whole trees can be cured of the phony peach virus by immersion for 40 minutes in water at 48°C.

The method has also been tried with herbaceous plants and it has been found possible to cure such plants as cucumber of cucumber mosaic virus, tomato and tobacco of tomato aspermy virus and abutilon (the flowering maple) of abutilon mosaic virus. This can be done by holding the entire plant at a high temperature in air for a period of some days. Generally only those parts formed during and immediately after treatment are free of virus, the virus invading them sytematically when the plants are returned to normal temperatures (Kassanis 1954). However if cuttings are struck from the new growth they will remain healthy. In other cases the virus is completely eliminated from the treated plant. Kassanis (1949) showed that potato tubers could be freed of leaf-roll virus by holding them at 37·5°C for 25 days but virus X was unaffected. Natural heat inactivation has probably been responsible for maintaining the potato variety Phulwa, grown on the Indian plains, free of leaf-roll virus for many years. The natural high temperature of summer storage is apparently sufficient to inactivate any leaf-roll virus present in the tubers but the disease becomes common if seed tubers are kept in cool storage. The disease is also common in crops of other varieties for which seed is brought from the mountains (Bawden 1956; Thirumalachar 1954).

A number of factors determine the success or otherwise of the heat treatment method, the main ones being the thermal inactivation curves characteristic of the virus and of the host. Success is more likely with viruses which have low, rather than high thermal inactivation points. However even those with high thermal inactivation points may be successfully inactivated if their temperature coefficient of thermal inactivation is small since longer treatments at temperatures well below the thermal inactivation point may be successful. On the other hand those viruses which have a high thermal inactivation point and a large temperature

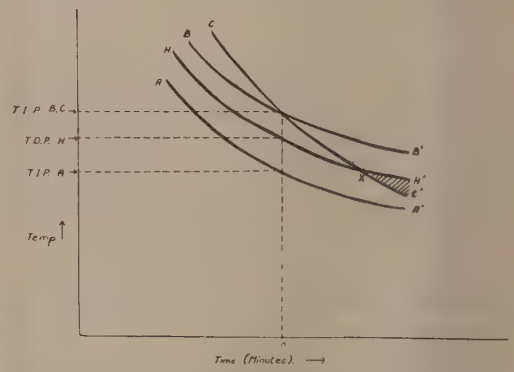

Fig. I.—Thermal Inactivation Curves of Viruses (A, B, C) and host (H.).
T.I.P. = Thermal inactivation point.
T.D.P. = Thermal Death Point.
T.C.T.I. = Temperature coefficient of Thermal Inactivation.
A.A¹ Thermal Inactivation Curve for virus with low T.I.P. and large T.C.T.I.
B.B.¹ T.I. Curve for virus with High T.I.P. and large T.C.T.I.
C.C¹ T.I. Curve for virus with High T.I.P. and small T.C.T.I.
H.H¹ T. Death Curve for host*
A can be inactivated without killing the host, over the whole temperature range illustrated.
B. cannot be inactivated without killing the host at any point over the temperature range illustrated.
C. has the same T.I.P. as B but can be inactivated without killing the host by treatment at any time temperature combination within the area C¹ x H¹.

*This is a rather simplified representation. The thermal death curve will vary for different tissues within the one host plant. The killing of buds depends on the killing of a critical minimum number of cells within them and the killing of individual cells depends on the inactivation of a critical minimum number of sensitive molecules (see Price & Knorr 1956).

coefficient of thermal inactivation do not offer much prospect of success with heat therapy, except of course in hosts which have similar properties. The relation between thermal inactivation point and temperature coefficient of thermal inactivation is represented in Figure 1. It must however be remembered that the thermal inactivation curve of the virus *in vitro* is not necessarily the same as it is in the host and also that the thermal death curve of the host may be altered by infection.

Figure 1 shows that a slight change in the thermal death curve of the host may assume critical importance and for this reason the conditions under which the plant is treated need to be carefully controlled. For example in strawberries—many varieties of which have been heat treated for the production of virus free foundation stocks—it is found that old pot-bound plants will survive better than young vigorously growing plants. They also survive better when they are brought up to the maximum temperature gradually rather than being transferred straight from normal temperatures to those at which treatment takes place. Survival is very much better at low atmospheric humidities and finally lighted conditions give better survival than dark conditions. With attention to all these precautions strawberries will stand up to 14 days at 37°C. It has been found with strawberries that it is more difficult to inactivate the persistent viruses than the non-persistent ones but nevertheless a number of varieties have been freed of both types by this method.

Although no therapy is involved the technique of apical tip culture is worthy of mention. It appears that the systemic invasion of plant parts does not quite keep pace with the apical growth of shoots and if an apical tip from a diseased plant is removed onto a nutrient medium or grafted onto a healthy stock there is a fair chance that the plant which develops will be virus free. In this way virus free stocks of a number of potato (Morel and Martin 1955), sweet potato and chrysanthemum (Holmes 1955, 1956) varieties has been developed.

Chemotherapy of Virus Infected Plants

Efforts are also being made to develop chemical means of curing virus infected plants, but progress has been slow. This is not unexpected in view of the fact that all the plant viruses so far studied have been found to be nucleoproteins closely related to the normal nucleoproteins of their hosts. The relationship between the host plant and the virus is a very intimate one, the host not only providing the materials from which the virus is manufactured but also apparently taking an active part in the process of manufacture. The nucleic acid component of the virus nucleoprotein appears to enter the genetic mechanism of the host cell and use the normal cell enzymes to produce more virus (Best 1956). It is therefore clear that any substance which will destroy virus particles in the host is also very likely to cause serious disruption of the host's metabolism.

There remains the possibility that some other viruses may not be so simple in their chemical constitution. If they have some metabolism of their own and play a more active part in their own synthesis it is more likely that they could be destroyed by chemotherapeutants which would not have similar effects on the host cells (Bawden 1955).

Although a number of substances which will inhibit virus multiplication have been discovered none has yet been found to be capable of destroying virus particles already synthesised. However there is still some prospect that the inhibitors of multiplication will be useful as chemotherapeutants in that some of the less stable viruses are continually being broken down and depend for their continued existence in the plant on continual synthesis. If multiplication can be inhibited for a long enough period the host may eventually be left in a virus free condition.

Chemotherapy of bacterial and fungous diseases

Leaving aside the heat treatment of seeds and the use of high temperatures to suppress the development of fruit rot during ripening (Tindale, Jenkins and Peggie 1958) the methods of therapy used against fungous and bacterial diseases are mainly chemical.

A number of successful methods of chemotherapy have been developed but they are mainly those used against superficial infections, e.g. the use of D.N.O.C. against crown

gall (Ark 1941), sulphur against powdery mildew and mercury sprays to eliminate *Venturia inaequalis* from newly established apple scab infections.

There are few instances of successful systemic chemotherapy i.e. where the therapeutant is introduced into the internal tissues of the plant and is transported to the sites of infection. However this method has been applied with some effect against both local and systemic infections. The effectiveness of the sulphonamides, applied through the roots against rust in wheat is an example of systemic chemotherapy against local infection (Rudd-Jones 1956). The sulphonamides, however, suffer the disadvantage that they are effective only against obligate parasites, the amounts which have to be applied to build up a concentration effective against facultative parasites generally being phytotoxic. Aroxyalkylcarboxylic acids applied to the soil have been shown to reduce Botrytis leaf spot in beans (Crowdy and Wain 1951), but again there are phytotoxic effects.

The development of systemic therapeutants for use against systemic fungous diseases is one of the most urgent needs. A number of compounds have been found which are more or less effective when used in this way. Probably the best known is 8-quinolinol sulphate which has been shown to be effective against Fusarium wilt of carnations (Stoddard and Dimond 1951) and the Dutch Elm disease (*Ceratostomella ulmi*) (Horsfall and Zentmeyer 1942). However the effect appears to be only a mitigation of symptoms and not a cure because if treatment is discontinued the disease reappears. Similar effects have been obtained on various diseases with other compounds including numerous derivatives of 8 quinolinol, diaminoazo benzene derivatives (Howard 1941), sodium and potassium benzothiazolyl-2-thioglycolate (Hoffman 1953) and urea and malachite green (Horsfall and Zentmeyer 1942). These compounds all have some effect in reducing the severity of symptoms or delaying their onset but none is able to produce a cure. Despite continued treatment the plant will eventually succumb. The mechanism of action appears to be the antidoting of toxins produced by the fungus. Whilst such a mechanism may provide a solution to the problem in annual crops it is unlikely to be acceptable where perennial crops or trees are involved.

Antibiotics

A group of substances which has been extensively studied in recent years is the antibiotics. The first ones which were tested were those which had been selected and developed for their action against bacteria pathogenic to man and it is not surprising that they were not very effective against plant pathogens. It was, however, a significant finding that they could be absorbed and translocated systematically within plants.

Of the antibiotics developed primarily for medical purposes streptomycin is the one which has shown the most promise against plant diseases, being active against both Gram-positive and Gram-negative bacteria. It is fairly phytotoxic having an effect on chlorophyll synthesis, but it has been used successfully against a number of bacterial diseases including tomato canker (*Corynebacterium michiganense*), tobacco wildfire (*Pseudomonas tabaci*) and fireblight of apples and pears (*Erwinia amylovora*) (Ark and Alcorn 1956). Müller, Mackey and Friend (1954) reported the interesting finding that concentrations of streptomycin well below that required to affect the growth of *Phytophthora infestans in vitro* conferred a marked degree of resistance against blight to susceptible varieties of potato and tomato.

Following the success of streptomycin a search was begun for antibiotics which were primarily fungicidal in action, and a number have already been discovered—antimycin, helixin, viridin, griseofulvin, tricothecin, actidione and candicidin among them.

Antimycin has been shown to give experimental control of the apple scab fungus (*Venturia inaequalis*) and griseofulvin has been used with some success against a number of diseases including club root of crucifers (*Plasmodiophora brassicae*) (Rosser 1957). Outstanding results have been obtained with acti-dione, first discovered as a by-product of streptomycin production. A concentration of

10 p.p.m. has been shown to eliminate *Coccomyces haemalis* almost completely from cherry leaf spot lesions (Petersen and Cation 1950). Wallen (1955) has reported perfect control of wheat stem rust with spray applications of Acti-dione in glasshouse experiments. It is also very effective against the downy mildew fungi but its phytotoxicity is high.

New antibiotics are being discovered continually and in view of their capacity for systemic translocation and their marked specificity of action there is little doubt that they will become increasingly important as therapeutants.

Future Developments

A discussion of possible future developments is bound up with a consideration of those situations in which other methods have failed but where therapy may succeed. Research will naturally be directed into these channels and the greatest developments are likely to occur in them.

In annual plants the necessity that they should provide an economic return in a single season will severely restrict the development of practical methods of therapy. There is a tendency to look to therapeutic measures as the answer to the problem of virus diseases in annual crops but the development of immune or tolerant varieties, the use of trap or barrier crops, the adjustment of planting times and cultural practices, certification schemes and perhaps the development of effective vector repellants and inhibitors of infection are as likely to give economically sound solutions.

In perennial plants an important distinction to be borne in mind is that between what may be called annual diseases—i.e. those which must be re-established by fresh infections each season—and perennial diseases—i.e. those which are systemic and persist from one season to another in the host without the necessity of re-infection. The annual diseases generally assert their influence by the mass effect of the destruction of tissue at numerous points of infection. Scab in apples (*Venturia inaequalis*) and bacterial blight in walnuts (*Xanthomonas juglandis*) are examples. With these diseases once the tissue is infected it is very soon dead and no amount of therapy will bring it back to life. Under these circumstances the prospects of the successful use of therapy are considerably reduced.

The systemic perennial diseases are those in which therapy is potentially of the greatest benefit. A few of the most serious diseases of this type are Oak wilt (*Chalara quercina*), the Dutch Elm disease (*Ceratostomella ulmi*), Chestnut blight (*Endothia parasitica*), *Armillaria* rot of a wide range of fruit and forest trees and black heart (*Verticillium*) of stone fruits. Some of the perennial diseases are the result of attack by very destructive pathogens —for instance *Armillaria mellea*. These pathogens destroy the infected tissues and there is no chance that recovery of the affected parts would follow the elimination of the pathogen. Nevertheless it would be very useful to have a therapeutant which would check the advance of the pathogens into healthy tissues. Such an agent would be very helpful in the process of limiting and finally eliminating the disease.

In other cases such as *Verticillium* in stone fruits the pathogen is not so completely destructive and there would seem to be a fair chance of recovery or replacement of damaged vascular tissues if therapy were successfully applied at an early stage.

Another important distinction is that between the facultative and the obligate parasites. The obligate parasites of necessity, exist in intimate contact with living cells and the final transport of a therapeutant from the host's tissues to those of the parasite should follow easily as a result of this close contact. On the other hand the intimate and balanced relation between the physiologies of host and parasite would appear to pose great difficulties in the selection of therapeutants which will be effective against the parasite but leave the host undamaged.

A number of serious virus diseases of perennial crop plants and of trees have now been recorded and despite the inherent difficulties already discussed considerable effort will be expended in the search for therapeutic measures for such diseases. The success of this search could well depend on the progress of

fundamental research into the nature and reproduction of viruses.

The development of therapeutic measures in perennial plants should be made easier by the fact that a serious but temporary derangement of the plants' metabolism may be permissible whereas in annual plants such a check would nullify the usefulness of the treatment. On the other hand perennial plants are exposed to the risk of re-infection for a longer period than are annual plants.

The most likely future develoments are the discovery of practical therapeutic treatments for the control of systemic diseases in perennial crops and the extension of existing methods for production of disease free foundation stocks. It is most probable that the development of therapeutic treatments will continue to supplement but never supplant preventive measures in plant disease control.

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THE RELATIONSHIPS OF PLANTS TO VIRUSES

N. H. WHITE

Before discussing plant and virus relationships it is important to have a clear understanding of the meaning and usages of terminology in Plant Pathology concerning pathogen and host relationships.

Distinction should be made in the first instance between *inoculation* and *infection*. Since viruses can only gain entry into plants through wounding, a plant is inoculated with a virus when the virus inoculum is introduced into it. It is infected when the virus multiples in the cell of the plant irrespective of whether the plant shows disease symptoms or whether there is any spread of the virus from the infection court. The term *resistant to disease* though widely used is strictly incorrect because what is meant is that the host plant tissue resists the development or spread of the virus or pathogen so that symptoms of the disease do not develop.

Many plants under field conditions are never affected with a virus disease because they are never exposed to a virus mainly because the virus vector does not visit them. These plants may be susceptible to virus infection and many have been shown to be susceptible through experimental inoculation. Under field conditions these plants escape virus disease.

Some plant species or varieties are resistant to virus infection and in terms of plant pathological usage these are *immune* from infection. There is a difference in the meaning of the term immune as used by animal pathologists and plant pathologists. Immunity as used by animal pathologists is concerned with antibody production in the blood vascular system of animals. In plants no such phenomenon exists, though the so-called cross protection phenomena in plants may superficially resemble that of acquired immunity in animals. This difference appears to arise from the fact that plants do not possess a blood-vascular system.

Plants may be placed into three categories depending on their relationship with viruses, namely: resistant to infection; resistant to systemic infection; and susceptible to systemic infection.

Plants Resistant to Infection

In plants resistant to infection, the active virus either fails to enter the appropriate host cell or if it does enter, it is unable to multiply there. One of the main reasons why active virus fails to enter a host plant cell is the presence of inhibitors of infection in the virus inoculum, either as constituents of plant sap (Bawden 1954) or in the saliva of insect vectors (Day and Irzykierwicz 1954). Active viruses that enter the plant cell may fail to multiply because of the presence in the cells of inhibitors of virus increase (Bawden 1954); because of the absence of suitable sites for attachment for the virus in the plant cell (Bawden 1953); or because the cell may be deficient in specific substrate material or enzyme mechanisms and thus be an unsuitable environment for virus synthesis. There is however no direct evidence so far to establish the real cause of plant

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resistance to virus infection. A variety or species of plant may be resistant to infection by a specific virus but susceptible to infection by another virus. Thus *Petunia* is resistant to infection by potato virus X, but is susceptible to infection by potato virus Y.

Varieties of a species of plant may also differ in their susceptibility to infection by a specific virus. For example most varieties of potato, *Solanum tuberosum,* are resistant to infection by tobacco mosaic virus, but a few varieties like "Green Mountain" are susceptible to infection by TMV. Resistance to infection by a virus therefore appears to reside in a property of the plant host which prevents virus multiplication after it has entered the host cell. This property of the plant is present all the time and does not develop as a result of inoculation with a virus, and has been shown to be heritable (Holmes 1954). Plants that are resistant to virus infection are of course immune from the disease caused by the virus, and this is the ideal type of resistance to be achieved in plant breeding.

Plants Resistant to Systemic Infection

In plants showing the symptoms of a virus disease the virus is usually distributed systemically throughout the plant and in most cases can be detected in all tissues of the plant. In some plants the virus is confined to the infection court and is prevented from becoming systemic. These plants are susceptible to infection but are resistant to systemic disease.

There appears to be two ways in which plants may limit the spread of viruses once infection has taken place. Firstly by confining the virus to primary or local necrotic lesions which result from the collapse of infected cells that are hypersensitive to virus synthesis. Secondly by the development of antagonism to virus synthesis in infected tissues. In both types the mechanism for resistance develops as a result of infection and it is therefore a dynamic defence reaction that leads to resistance to systemic virus disease.

The local necrotic lesion reaction may develop in experimental inoculation by mechanically wiping virus inoculum on to leaves of hypersensitive hosts, as when TMV is inoculated onto leaves of *Datura stramonium,* or when potato virus X is inoculated on to leaves of *Gomphrina globosa* (globe amaranth). On these hosts the respective viruses do not become systemic because the virus is confined to the necrotic tissue of the lesion, since no trace of the virus can be detected in the tissue beyond the margin of dead cells of the lesion in these plants. However the formation of local necrotic lesions on inoculated leaves does not necessarily ensure that there will be resistance to systemic infection of the plant, for in some plants, like *Nicotiana rustica* inoculated with TMV, local necrotic lesion development is followed by systemic necrosis.

The reason why viruses are confined to the local necrotic lesions in some hosts and not in others is not known, but there is some correlation between the rate of local lesion development and the subsequent systemic spread of the virus in any given host. Thus when TMV is inoculated on to *Datura* or *Nicotiana glutinosa,* the local necrotic lesions appear in three and four days respectively and in these hosts the virus does not become systemic whereas when TMV is inoculated on to *N. rustica* the local necrotic lesions do not appear till the fifth day and on this host TMV becomes systemic.

Rapidly developed local necrotic lesions tend to become limited in ultimate size and they usually confine the virus to the lesion, whereas slower developing primary necrotic lesions tend to become more extensive, and less likely to confine the virus to the primary lesion. Thus TMV on *Datura* produces discrete small local necrotic lesions in three days at temperatures of 20-25°C and does not become systemic, whereas Tomato spotted wilt virus on the same host at the same temperatures produces local necrotic lesions in six days which continue to increase in size and the virus eventually becomes systemic.

Two factors seem to be involved in local necrotic lesion formation. They are host sensitivity to virus synthesis, and the rate of virus synthesis. Both these factors may be affected by light conditions (duration and intensity) and by temperature, (Bawden and Roberts

1947, Matthews 1953a, 1953b). The sensitivity of some hosts to certain viruses may be increased by high light intensities or high temperatures, while the sensitivity of other hosts to other viruses may be decreased by these light and temperature conditions. The resistance to systemic infection through local necrotic lesion development may be changed to susceptibility to systemic infection by altering light and temperature conditions of the inoculated plants. Thus tobacco hybrids carrying the NN or Glutinosa factor for hypersensitivity to TMV and giving the local necrotic lesion reaction are resistant to systemic infection at temperatures below 75°F., but above this temperature local lesion development is slower and is followed by systemic infections. In these plants significantly more virus is formed in the local lesions below 75°F. than at temperatures above this.

There appears to be a direct relationship between the amount of virus formed and the severity of local lesion development in spite of statements to the contrary in the literature (Hutton 1951). This would indicate that the effect of light and temperature on the local lesion reaction may be the result of different rates of virus synthesis. Thus tomato aucuba mosaic virus produces local necrotic lesions on *N. glutinosa* at temperatures below 30°C., but above this temperature only local chlorotic lesions are developed, and more virus is formed below 30°C. than above this temperature.

The localisation of the virus to the infection court through a necrotic reaction of the host has been reported for natural field conditions, as, for example, when hypersensitive plants are inoculated by means of vectors. (Jones, Vincent and Burk 1945; Hutton 1945, 1948; Cockerham 1945; Cockerham & M'Ghee 1947). This is referred to as "field resistance" by these authors.

The limitation of a virus infection and its eventual elimination through antagonism to virus synthesis is claimed by Hutton (1951) to be due to the presence of virus-inactivating systems in plants resistant to systemic disease (Hutton and Peak 1953). It is contended that resistance to infection; resistance to systemic infection through the hypersensitivity local necrotic lesion reaction; and virus inactivating systems are phases of the same reaction and are dependent on similar host genes. Hutton (1951) postulates that differences in the nuclease system causes an interruption to the development of virus in these plants. He found that temperature affects the type of host reaction to virus inoculation. Thus potato seedlings giving the local necrotic lesion reaction to potato virus X or Y inoculations when grown at temperatures of 60°F. to 70°F. were not systemically infected, and were apparently immune, when grown at a temperature of 90°F, (Hutton 1951). Also when *Lycopersicum peruvianum*, grown at 90°F, were inoculated with the ringspot strain of tomato spotted wilt virus, the virus was localised in the infection courts with no systemic spread. But when these plants were grown at 60-87°F, and inoculated with the same virus they were systemically infected (Hutton & Peak 1953).

Plants Susceptible to Systemic Infection

In plants susceptible to systemic infection, local lesions, necrotic, ringspot or chlorotic, may or may not develop on the mechanically sap-inoculated leaves. In the more sensitive hosts local necrotic lesions of the spreading type develop on the inoculated leaves and are followed by systemic infection which usually results in systemic necrotic symptoms. For example when TMV is inoculated on to *N. rustica* or tomato spotted wilt virus is inoculated on to *Datura stramonium*. In less sensitive hosts the necrotic ringspot type of local lesion may develop, and in a still less sensitive host local chlorotic lesions may develop. In both types of host the development of local lesions are almost invariably followed by systemic infection resulting in either ringspot or mosaic symptoms, e.g. cucumber mosaic virus on *N. glutinosa* and *D. stramonium*. The local lesion reaction of these hosts are conditioned by light and temperature, and some viruses, giving local necrotic lesion followed by systemic necrosis on their host at high temperatures and light intensity, will induce only local chlorotic lesions followed by systemic mosaic mottle

on their host under low light intensity and temperature. For example tomato spotted wilt virus causes local necrotic lesions followed by systemic necrosis on *Datura* at high light intensity and temperature but only local chlorotic lesions followed by a systemic mottle at low light intensity and temperature on the same host.

In most plants susceptible to systemic infection by viruses there is no visible reaction in the mechanically inoculated leaves. In these plants the systemic symptoms, usually of the mosaic type, develop only in tissues formed after systemic invasion of the virus has occurred. The tissues of the plant are affected according to the stage of development of the plant organs and their sensitivity to virus concentration in the cells. In fully mature tissue, leaf-rolling or yellowing or premature abscission is all that will result from systemic infection, and not all plants will react in this way. In some plants leaves that are immature at the time of systemic invasion will show vein clearing, and vein-banding, but the full expression of systemic virus infection is revealed in tissue arising from virus infected primordial tissue. The intensity of all these reactions is conditioned by environment, especially light intensity and duration, and temperature.

In some virus-host plant combinations in which the plant becomes systemically infected and the initial systemic symptom is severe necrosis, the plants appear either to partially or to completely recover from the disease. The virus of top wilt necrosis of broad bean usually kills the whole plant, but in plants that survive, a secondary phase appears as extreme dwarfing, distortion and mottling of the new shoots. The tobacco ringspot viruses producing systemic symptoms on different hosts initially as mosaics or ringspotting but later these hosts appear to completely recover from the disease, though virus is still present in the symptomless leaves. Unfortunately no one seems to have related concentration of the virus in cells to severity of symptoms in these virus-host plant combinations.

There are however, many plants which tolerate systemic virus infections. In most of these there are no visible signs of disease though the virus is present. For example: potato virus X in potato, and dodder latent mosaic virus in *Nicotiana rustica, N. glauca, N. tobacum* and *Brassica incana.* The term latent infection has been applied to these virus-host combinations, but this is not comparable to latent infections by other pathogens. True latent infections are those that remain dormant for some time and then become active producing symptoms of disease in the same host. Potato virus X and dodder latent mosaic virus never produce symptoms in their respective potato and dodder host plants and they are not dormant in their symptomless hosts as in the case of true latency. They are however capable of inducing symptoms in other hosts when transferred from their symptomless hosts.

In some tolerant hosts only mild systemic symptoms develop and the growth and yield of these plants is not seriously impaired. In combating virus diseases host tolerance is often used if resistance to infection has not been found. The reason for host tolerance is not known, but evidence obtained by the author (unpublished data) suggests that less virus is formed in tolerant hosts than in hosts developing severe systemic symptoms. If this is generally true then it appears that tolerant hosts either contain inhibitors of virus increase or are able to inactivate some of the newly synthesised virus. This presents a formidable problem of virus investigation as it is difficult to demonstrate *in vitro* what takes place *in vivo* with viruses in plant cells. (Bawden 1954). If tolerant hosts limit virus increase, then they could be considered as possessing properties of resistance and would therefore constitute a form of resistance to systemic infection resembling that suggested by Hutton (1951).

To summarise the relationship of plants to viruses it may be stated that in broadest terms, resistance to virus infection is the general rule among plants and susceptibility to infection the exception. More specifically some plant species or varieties are susceptible to local infection but resistant to systemic disease. Others are susceptible to systemic infection resulting in symptoms of varying severity in

the more susceptible plants or in varying degrees of tolerance in the less susceptible plants in which there are either no symptoms or mild symptoms of disease.

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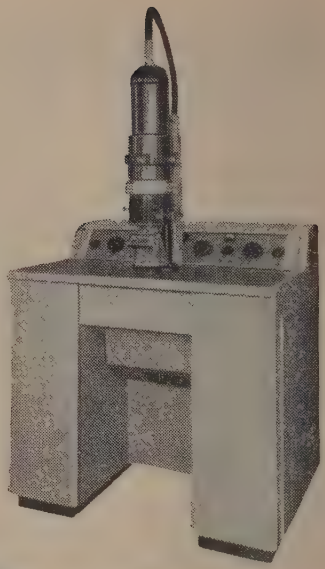

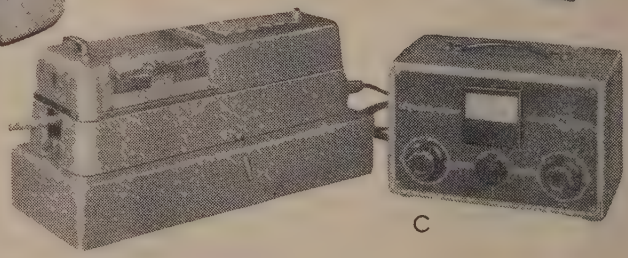

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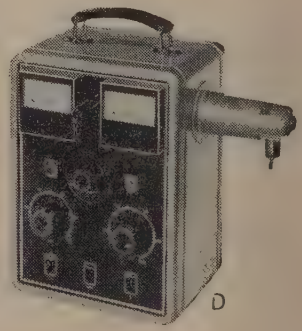

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Articles

SUPPLEMENTARY FEEDING OF SHEEP AND EXPERIMENTAL DESIGN

H. P. SCHAPPER, M. L. PARKER and
D. W. G. TRELOAR

For individual farmers, and for the national economy, there is a major and continuing economic problem of deciding what are the optimal levels and combinations of supplementary feeds and other inputs to be applied to each animal and acre used in agriculture. The actual applications made may be viewed as the results of decisions made by farmers. These decisions, which in numerous instances have hardened into custom, are themselves the outcome of a complex of forces including the farmer's expected nett return to the application of a particular input relative to that of another input, his income situation, his creditworthiness, his farming goals, and so on.

One of the most important responsibilities of agricultural research and advisory services is to give farmers precise quantitative information on responses or changes in yields per acre and per animal associated with changes in the amounts and the combinations of inputs applied to land and livestock. It is the provision of this service which constitutes the sole reason for a large part of the experimental work of State Departments of Agriculture. Without this service, the best levels and combinations of resource application must be guessed at by farmers. Such guesswork can be modified only by the farmer's observations and experiences of his own property between unlike seasons and by comparisons between unlike properties, namely his own and others which usually differ widely in area, soils, capital and management. This suggests that, at least wherever precise quantitative response information has not already been obtained, land and livestock, for instance, may be over- and under-fertilized and supplemented respectively. These mistaken decisions, made on individual farms throughout Australia, do not cancel out.

Although it is not possible to assess the losses incurred by maladjustments of supplements to sheep and of sheep to acres in the absence of the desired experimental results, nor to assess the gains that may accrue if farmers were in possession of these results, these respective losses and gains may be substantial. The Australian annual supplementary feed bill of about £60 million suggests that scope exists for large scale adjustments.

In a review of agricultural experiments in Western Australia, Pearse (1955) noted the absence of economic orientation. It is the purpose of this article to provide such orientation by reference to experimentation on the supplementary feeding of sheep. The analysis is undertaken to show that unless certain conditions are observed by agricultural scientists in sheep feeding experiments carried out at the final applied level, the results of these experiments are either valueless or only of limited application. This article will also reveal the existence of considerable gaps in applied knowledge of supplementary feeding of sheep which allow continued dissemination among farmers of recommendations which are dubious

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or wrong. Finally, some suggestions are made for the establishment of and improvements in the design of experiments on the supplementary feeding of sheep from which results can be soundly applied to individual farms.

ANALYSIS OF EXPERIMENTAL DESIGN

Objectives of Supplementation

The design of efficient and meaningful supplementary sheep feeding experiments at the final applied level depends primarily on the specific objective of supplementation. Supplementation may be for survival, flushing, steaming-up, prevention of nutritional disorders, production or increasing rates of growth.

With adult sheep either it pays to feed for survival, to feed above survival for a specific level of production or purpose, or it does not pay to feed at all. In each case the particular objective depends on relative costs and on prices of feed, product, replacements and surplus sheep.

Survival suggests a minimum level of supplementation and where survival is the objective this minimum level is also the maximum. A higher level of supplementary feeding is warranted only where it can be shown that feeding for production is an economic proposition. The objective of survival-type feeding experiments is to establish an appropriate maintenance point and to determine the least-cost ration required to keep sheep at this point. Problems of this type have been partly solved by Franklin and Sutton (1952) and Franklin *et al.* (1955). For production type experiments the objective is to determine least-cost rations over the whole range of physical production from survival to maximum.

The distinction between survival type experiments, (and these include experiments on supplementary feeding for flushing, steaming-up, control of pregnancy toxaemia, etc.) and production type experiments, is that between locating a specific point on the one hand and locating a full range of points on the other. If the results of such experimentation are to serve as reliable guides to farmers a clear distinction in experimental design between the various purposes of supplementation must be made. This has been done in some cases (Underwood and Shier, 1941), but often the distinction has not been apparent (Shier, 1929; Riches, 1931).

The Production Function

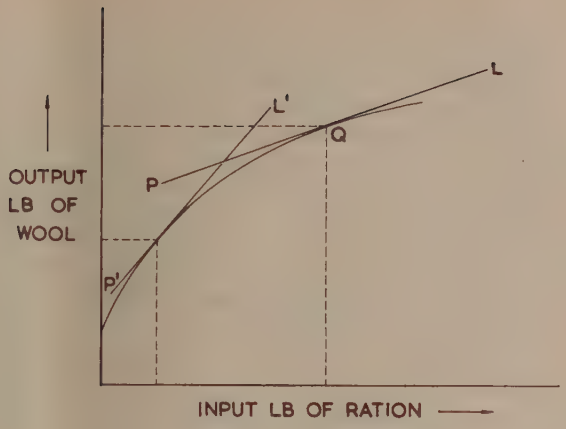
Locating a full range of points leads to the establishment of a *production function*. This depicts the relation between amounts of supplement and levels of production.. But production functions cannot be derived from experiments which examine one or a number of feedstuffs without giving any consideration to levels of feeding within each ration (Sutton, 1920; Shier, 1929; Riches, 1931; Underwood, Shier and Cariss, 1943; McClymont). Procedures of this type establish merely one point on a function. It is important that the *shape* of the function be known and this obviously requires at least three points. Given its shape and price and cost data the most profitable level of production may be predicted.

As long as the additional production multiplied by its price is greater than the necessary additional input multiplied by its cost, nett profits can be increased. They will be at a maximum where these amounts are equal. This is at point Q in Figure 1. Here the price-cost ratio, given by the slope of PL, is equal to the slope of the input/output ratio (which is the production function) at the point of their tangency.

But price ratios are likely to vary with time. It is important, therefore, that the shape of the production function should be known over its full range so that feeding levels can be varied to comply with movements in costs and prices; i.e., in Figure 1, with varying slopes of PL e.g., P'L'. This is not possible where experiments are designed to cover only the narrow range of currently accepted levels of supplementation which may or may not be optimal in terms of economic efficiency.

Finally, unless the experiment establishes a full function, faulty recommendations are likely to be made from its results. There is a tendency to assume that points such as A, B

Figure 1—A production function with price-cost data applied to show economically optimum levels of production.



and C in Figure 2 establish a production function, when, in actual fact, each is an isolated point on one of the three functions relating to the three different feedstuffs used in the experiment.

Rates of Substitution

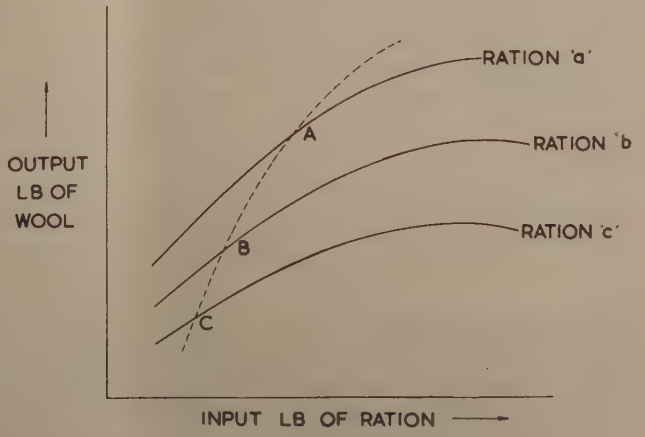
Where supplementary feed rations are composed of two or more feedstuffs it is necessary to determine the rate at which each feedstuff substitutes for the other. Commonly, it is tacitly assumed that the rates of substitution are constant. If they were, then, as shown in Figure 3:

1. *isoquants* (lines of equal quantities of wool production from varying combinations of hay and grain) would be linear;

2. successive isoquants would be parallel to one another.

In other words, the rate at which the constituents of the ration substitute for one another would not vary with changing levels of production.

Figure 2—A production function falsely derived from 3 different functions.



In fact, however, isoquants probably are non-linear, indicating that the marginal rate of substitution does change when the ratio of one feed declines relative to the other. Also, between any two levels of production, the constituents of the ration are likely to substitute for one another at different rates. These points are illustrated in Figure 4. The isocline FL connects points A, B and C where isoquants have the same slope. It is apparent that since the isocline is non-linear it cannot coincide with any "fixed-ration" line such as FR.

Experiments which do not take into account the manner in which feedstuffs substitute within a ration (Franklin *et al.*, 1957) are oversimplified and inevitably neglect the economic aspect of supplementation. This point applies also to experimental findings which are given in terms of the intake of total digestible nutrients, crude protein or total nitrogen (Waite, 1956; Marston, 1948).

With a ration comprised of a fixed combination of inputs, it is possible to establish points such as D in Figure 5. This in no way indicates the shape of the isoquant EF, nor of the isoquants at higher or lower levels of output.

The shape of the production function in Figure 1 together with the cost-price ratio (line PL) determined the economically optimum level of feeding with a simple feedstuff. Similarly with a composite ration of two feedstuffs, the least-cost combination is determined by the shape of the isoquant (Figure 4) and the cost ratio of these feeds. In Figure 4 this least-cost combination is at D and E where isoquants and *isocost* lines are tangential. Each isocost line represents all possible combinations of hay and grain which can be obtained from a given outlay of funds. Its slope will change with changes in relative costs. To maintain the ration at its least-cost combination under such conditions, it is necessary that substitution rates be known throughout a complete range of supplementation.

Production per Sheep and per Acre

Supplementary feeding trials for wool production have been concerned only with production per sheep. This limitation is at variance with the financial needs of most farmers whose business concern is with wool production per acre. Where the farm as a firm (rather than a household) is concerned, the problem is that of organizing the variable resources at the farmer's disposal to maximize net profits. In the short-run the farm acreage may be considered as constant and the proportion of the farm devoted to sheep, rather than to cash crops, will be determined by wool/grain price ratios, rotational practices, etc. The variable inputs, namely the quantities of supplements and the number of sheep, therefore assume significance in problems of supplementary feeding. The goal of profit-maximization is then one of attaining the greatest net return per acre.

It is clear that, up to the present, most of the published results of applied research in supplementary feeding are from experiments which fail to meet one or more of the foregoing requirements. In brief, these requirements are that experiments be designed in accordance with the need, firstly, to make the objectives of supplementation specific, secondly, to establish a full range of points for the determination of a production function, thirdly, to determine the rates at which feedstuffs substitute for one another at different levels of production and finally to take into account rates of stocking. Until such time as the appropriate experimental work is carried out, recommendations made to farmers by extension services must be treated with reserve.

RECOMMENDED APPROACH

It is now our purpose to present and discuss an experimental model which will enable the economic aspects of feeding to be satisfactorily resolved. The procedure adopted is to select a hypothetical production function and to successively examine and modify it in the light of the foregoing requirements.

Because sheep husbandry workers are probably not familiar with the concepts and terminology, each step in the construction of the final experimental model is set out in detail. Firstly, a least cost ration is defined for specific levels of production to meet the first and third requirements. Secondly, the most profitable level of production is found. These give the

Figure 3—Isoquants indicating constant rates of substitution between hay and grain.

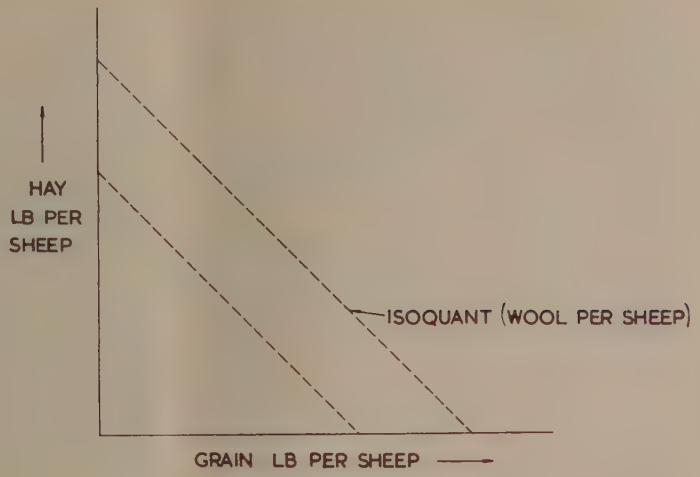


Figure 4—Isoquants with diminishing rates of substitution.

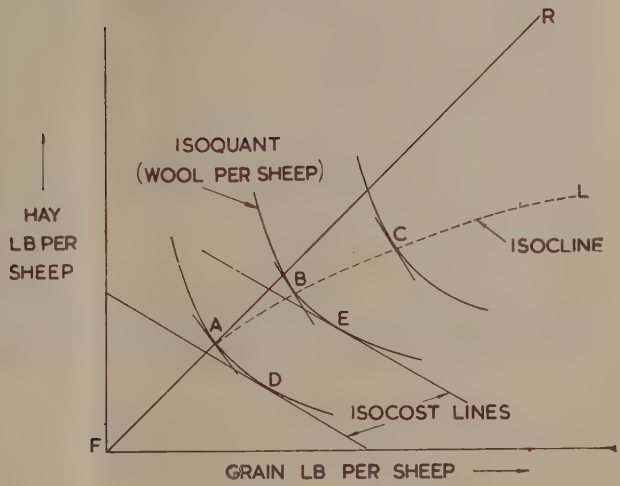
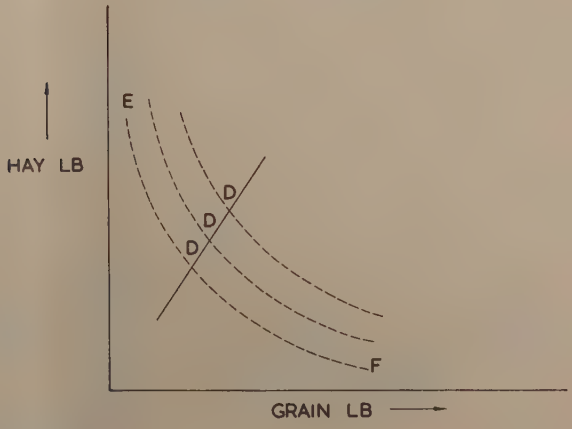


Figure 5—A single combination of inputs cannot establish an isoquant.



optimum levels of hay and grain and yields of wool for maximum net profit per sheep. Each of the production relationships is then transformed from a per sheep to a per acre basis to derive the final model which alone permits selection of the economically optimum levels of wool production per acre. This meets the fourth requirement.

The model is for the simplest possible case. It is assumed that the proportion of the total farm area available for sheep has already been determined and that the type of production is wool from adult wethers. Environmental conditions are assumed to be those in which a large proportion of sheep in Australia are found, namely those of cereal growing areas where there are prolonged seasonal shortages of pasture. Residual effects of supplementation between years have been ignored.

Hypothetical Production Function

The production of wool and the intake of various feedstuffs may be related by a production function of the type

$$W = f(GH.\ x_1\ x_2\ x_3\ x_4\ \ldots\ldots\ x_n),$$

where W is wool production per sheep in a specified period of time;
G is grain intake per sheep;
H is hay intake per sheep;
and $x_1\ x_2\ x_3\ x_4\ \ldots\ldots\ x_n$ refer to body size, inherent wool producing qualities of the sheep, labour and other inputs.

For the purpose of this analysis, the intakes of grain and hay are considered to be the only variable inputs. The manner in which they substitute for one another in the production of various quantities of wool is not known. But their rates of substitution are here assumed to be as shown in Figure 6, where the basis of measurement is the sheep.

The isoquants a, b, c and d represent different levels of wool production in an arithmetical progression from 0 to "d" lb per head. They are non-linear, indicating that the rate at which hay and grain substitute in the production of wool changes as the amount of one feed declines relatively to that of the other at constant production.

The straight lines OR_1, OR_2 and OR_3 correspond to rations with hay/grain ratios of 1:0, 2:1 and 1:2, respectively. The fact that distances between points of intersection of any one of these lines and the isoquants a, b, c and d increase as one moves along each of them from O signifies that diminishing returns to scale exist. To maintain equal increases in wool production per head, increasingly greater quantities of ration have to be fed.

The line ST represents the animal's capacity to ingest various combinations of hay and grain. The maximum wool production per sheep is at point M, where the highest attainable isoquant is tangential to the capacity line.

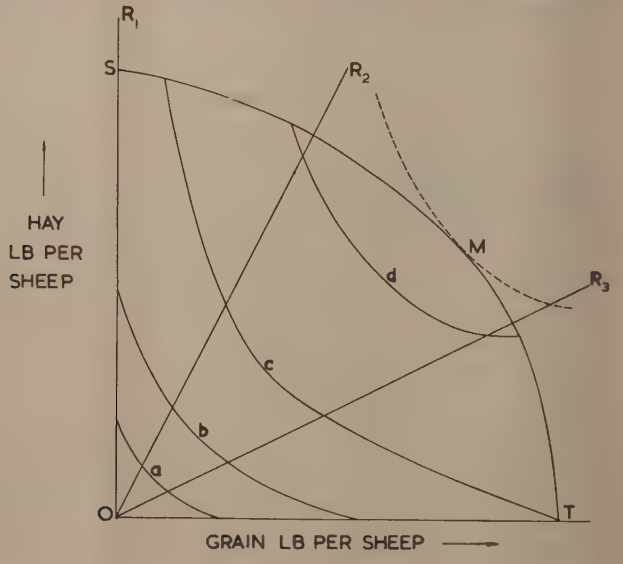


Figure 6—Substitution between hay and grain in the production of various quantities of wool per sheep.

M is the outcome of only one level and combination of hay and grain.

It may be that a minimum amount of roughage is necessary to maintain the well-being of the animal, the amount varying with the intake of concentrate. This refinement has not been included in Figure 6 because the work of Franklin (1955) suggests that sheep may be satisfactorily maintained solely on a diet of grain.

Least Cost Ration

Once given the information needed to derive Figure 6, it remains to determine the least-cost combination of hay and grain for specified levels of wool production per wether. The least-cost ration for a given production level is specified when the condition of the following equation is attained.

$$\frac{\Delta H}{\Delta G} = \frac{P_G}{P_H} \qquad \text{I}$$

where $\frac{\Delta H}{\Delta G}$ is the substitution ratio of grain and hay and P_G and P_H are the unit costs of grain and hay used.

Equation I may be solved graphically as shown in Figure 7. The line EF is an isocost line, the slope of which indicates the relative costs of hay and grain. EF is tangential to the "b" isoquant at J, and at this point equation I is satisfied for b units of production. The least cost ration will consist of OX_1 units of hay and OX_2 units of grain.

Similarly, where wool is to be produced at a, c or d lb per head (and the cost ratio is unchanged), the optimum combination of hay and grain is indicated by the points I, K and L, respectively. The curve of "increasing production at constant prices" (i.e. the expansion path OIJKLM) indicates that as output is expanded, the proportion of grain in the ration must be increased.

Maximum Nett Profit per Sheep

The problem now is to determine the one level of wool production per head which will return the greatest nett profit. This level is specified by the solution of the following equation:

$$\frac{\Delta W}{\Delta R} = \frac{P_R}{P_W} \qquad \text{II}$$

where W is the increment in lb of wool associated with R, the corresponding increment of the particular ration. $\frac{\Delta W}{\Delta R}$ is the marginal physical productivity of the ration in terms of wool, that is, the amount added to total wool production by a unit increase of ration.

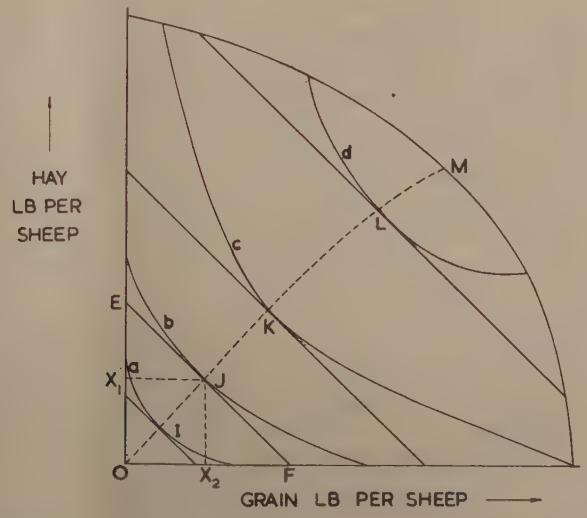


Figure 7—Cost data applied to indicate least-cost rations at various levels of wool production per sheep.

P_R and P_W are the unit prices of ration and wool respectively.

Whereas equation I specifies the least-cost ration regardless of the level at which it should be fed, equation II specifies the most profitable level of feeding of a particular ration, but does not specify the least-cost ration. These two requirements must be met simultaneously by the simultaneous solution of equations III and IV.

$$\frac{\Delta W}{\Delta H} = \frac{P_H}{P_W} \qquad \text{III}$$

$$\frac{\Delta W}{\Delta G} = \frac{P_G}{P_W} \qquad \text{IV}$$

The optimum combination of hay and grain and the level of wool production for maximum nett profit is now defined.

The solution of equations III and IV enables the selection of a point such as Q in Figure 8, where the wool/ration price ratio line is tangential to the production function OP. Here b lb of wool per head is to be produced by the input of OX lb of ration, with hay and grain combined, say, in the proportions OX_1:OX_2 as indicated at the point of intersection of the isoquant "b" and the expansion path OJM in Figure 7: i.e. OX (Fig. 8) = $OX_1 + OX_2$ (Fig. 7).

From per Sheep to per Acre

The previous analysis examined the wool production associated with different levels and combinations of supplementary feeds consumed by a fixed number of sheep grazing on a particular pasture. The optimum level of production was given in terms of wool per sheep.

In actual fact, the farmer is concerned not only with the level and composition of supplementary feeding, but also with the number of sheep to be fed. The relevant questions then become:

What is the least-cost combination of supplementary feed per acre and sheep numbers per acre, for a given output of wool per acre?

What level of wool production per acre will yield the maximum nett profit?

Figures 6, 7 and 8 must now be transformed to an acre basis. For a given rate of stocking, Figure 8 becomes Figure 8b. But the stocking rate must be included as a variable in the final production function.

Final Model

A number of functions similar to Figure 8b could be drawn for the identical supplementary ration but for different stocking rates (and vice versa). Compounding these gives a graph such as Figure 9 which refers to a ration of given composition fed as a supplement to a particular pasture. A separate figure would exist for each possible composition of the ration.

If a farmer is to produce B lb of wool per acre efficiently he must stock at OY_1 per acre and feed at the rate of OX_1 lb of supplement per acre, or stock at OY_2 sheep per acre and feed at the rate of OX_2 lb per acre, or employ some intermediate combination of stocking and feeding rates.

Similarly, limits may exist at other levels of wool production per acre, so that a rational area of production UVW (Figure 9) is defined. Production outside this area is irrational because resources may be recombined to give a greater product, or alternatively the same product may be obtained by using fewer resources (supplement and sheep). As higher levels of production are achieved, the area of rational production is likely to be reduced. This reduces the choice of alternative combinations of stocking and feeding rates until at the point of maximum production V, only one combination may suffice.

In finding the least-cost combination of feed per acre and sheep per acre for a given yield of wool, it is again necessary to apply price ratios. The least-cost combination exists where equation V is satisfied:

$$\frac{\Delta S}{\Delta R} = \frac{P_R}{P_S} \qquad \text{V}$$

where $\frac{\Delta S}{\Delta R}$ indicates the marginal rate at which the total feed intake (supplement and pasture) substitutes for sheep numbers;

P_R is the price per unit of this intake, and

P_S is the price per sheep calculated for the relevant time period.

Figure 8—Determination of the optimum level of feeding of a composite ration.

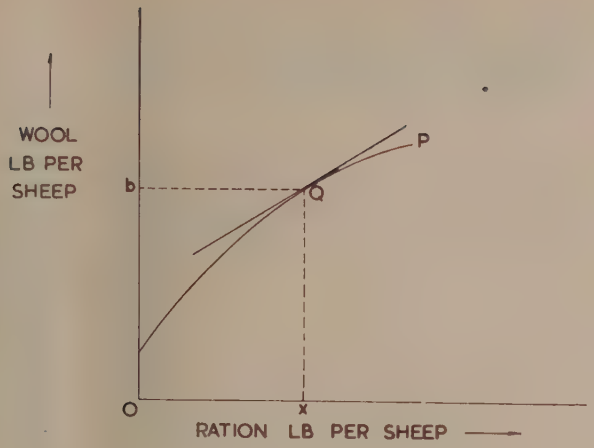


Figure 8b—Optimum levels of feeding transferred to a per acre basis.

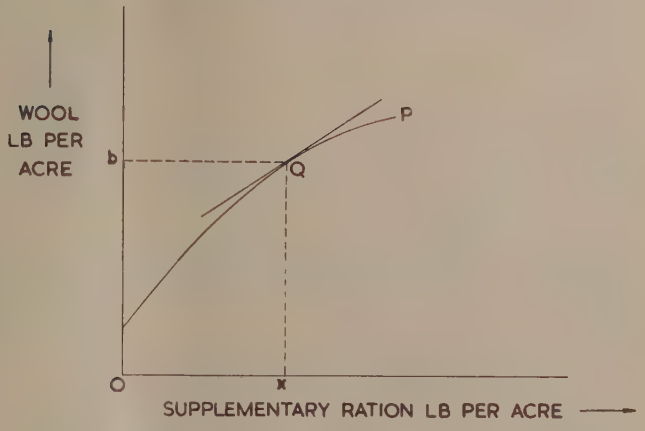
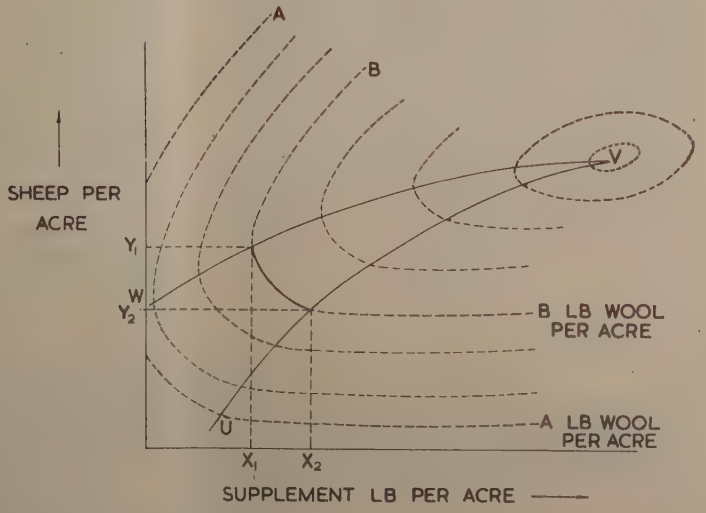


Figure 9—Rates of substitution between sheep per acre and feed input per acre related to the production of various quantities of wool per acre.



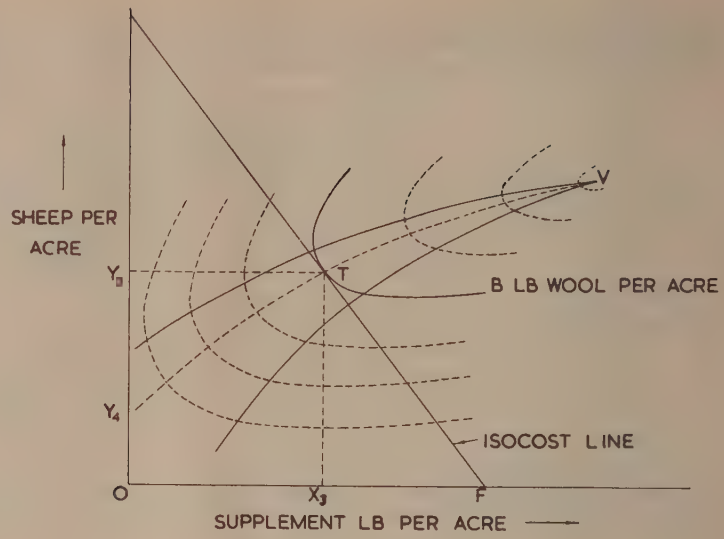


Figure 10 — Determination of the least-cost combination of sheep per acre and supplement per acre for particular levels of wool production per acre.

Graphically, this condition is met where an isocost line such as EF in Figure 10 is tangential to each isoquant.

The point of tangency with the B lb isoquant is at T. The least-cost combination in the production of B lb of wool per acre is then OX_3 units of supplement per acre and OY_3 sheep per acre.

However, in applying the least-cost equation, the assumption is that the most profitable level of wool production per acre is already known. In actual fact the level of production, and the stocking and feeding rates must be determined simultaneously. In doing this, it is necessary to refer to the expected price of wool.

The procedure again is to equate the partial derivatives of wool with respect to each input (i.e. ration and sheep) to the respective input-wool price ratio as shown:

$$\frac{\Delta W}{\Delta S} = \frac{P_S}{P_W} \qquad \text{VI}$$

$$\frac{\Delta W}{\Delta R} = \frac{P_R}{P_W} \qquad \text{VII}$$

This ensures that output is increased along the expansion path (Y_4TV) as long as the marginal value of the product exceeds the marginal cost. By solving the equations simultaneously, the optimum combinations of supplement and sheep per acre may be determined and the level of wool production per acre is then indicated.

It should be noted that this analysis assumes that the farmer's capital resources are unlimited. Where capital is limiting, total profits may be maximised by equating marginal returns to all resources at a value less than unity. This will result in production at a level below the optimum determined by equations VI and VII.

An extension of the above procedure is warranted in order to take into account types of pasture on which stock are grazed and to determine the effect of the type of feedstuff comprising the hay/grain supplement. This would involve,

1. establishment of hay/grain substitution ratios at different levels of wool production per head, for each stocking rate considered to be relevant to a particular district,

2. repetition of (1), using a variety of feedstuffs available within a district.

From such data a series of functions could be constructed on an acre basis to cover,

a. typical pasture situations

b. typical rations and combinations of rations.

Experiments of the type envisaged here require relatively large amounts of capital. This is certainly a drawback, but it is possible that they can be carried out within the framework of existing research budgets. The expensive capital items of land, livestock, fencing and water exist in large quantities on numerous farms in close proximity to most research stations throughout Australia. It is highly probable that many farmers would be prepared to provide, in kind, the capital costs involved in extensive grazing and supplementary feeding experiments. Technicians from the research station would, of course, make the necessary measurements etc. In this way, heavy capital expenditure is spread over a number of cooperating farmers and not borne solely by the research institution. This arrangement would not involve any sacrifice in accuracy of observations and may enable greater replication and more observations than are customary. Also, it could lead to closer relations between farmers and research station personnel.

CONCLUSION

It is clear that the majority of sheep farmers at the present time are unable to refer to the results of experiments for guidance with respect to the economically optimum levels of supplementation with hay and grain on either a per sheep or a per acre basis. This has been shown to be due to the lack of experimental results to which cost price data can be applied, and to the fact that the influence of supplementation on rates of stocking has not been included in the design of sheep-feeding experiments. The experimental model presented here constitutes an attempt to provide sheep husbandry scientists with a framework within which they can design experiments that will overcome these limitations.

Results of experiments designed in accordance with this model will provide the physical relationships required by extension officers and farmers if they are to make economically optimum decisions in the use of sheep-farm resources.

Acknowledgments

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Plant Growth Responses to some Australian Sources of Potassium

C. S. ANDREW and W. W. BRYAN

Potassium-bearing materials from Australian sources were tested as possible substitutes for imported potash salts. The ability of greensand, trachyte, calcined alunite, and potash alum to supply potassium in a deficient, low humic, gley soil was measured by the growth responses of Phaseolus lathyroides, Trifolium repens, and Medicago sativa.

In the first year 9.0 cwt of alunite and 6.35 cwt potash alum were each equal in effect to one cwt of potassium chloride (equal amounts of potassium). Heavier applications of alunite and potash alum depressed the growth of white clover and lucerne, but not of Phaseolus lathyroides. This depression is ascribed to aluminium toxicity. Greensand and trachyte were not effective in overcoming potassium deficiency.

Calcining of trachyte at 400°C did not increase the release of potassium.

The visual symptoms of potassium deficiency of Phaseolus lathyroides are described.

Australia's rapidly increasing use of potassium fertilizers, and her heavy dependence on overseas sources of supply give considerable point to the testing of local potassium-bearing materials. Few potassium-rich deposits occur in Australia and none is being worked at present for agricultural needs. Experiments were carried out in 1955-57 to test the ability of plants to obtain their potassium needs from greensand (glauconitic sand), trachyte, calcined alunite, and potash alum. A low humic gley soil (pH approximately 5.2) from Beerwah, Queensland, was used as it was known to be grossly deficient in potassium (Andrew and Bryan 1955). Moreover, it was considered that the potassium in these relatively insoluble materials would become available most readily under warm, moist conditions, i.e. under a summer rainfall regime.

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Earlier workers (e.g. Plumer 1918) have shown that relatively insoluble potassium-bearing materials can supply potassium to plants. Most workers emphasise the importance of micro-organisms, but have ascribed different functions to them. Their role is given as silicate decomposition and release of potassium (Bassalik 1913), or as increasing acidity and shifting the potassium equilibrium (Eno and Reuszer 1955), or as sulphur oxidation (McCall 1920; Rudolfs 1922), the two latter mechanisms being closely related.

Materials and Methods

The greensand (predominantly glauconite) was from Western Australia, the alunite from Bulahdelah, New South Wales, the trachyte from Mt. Beerburrum, Queensland, and the commercial sample of potash alum was made in Victoria.

The greensand and trachyte were ground in a ball mill and the fractions between 100 and 150 B.S.S. were used. The alunite had been ground to 200 B.S.S. and calcined at 400°C. In determining rates of application, the content of potassium was taken as 4.1 per cent. in greensand, 5.8 per cent. in trachyte (after Richards 1915) and alunite (R. G. Thomas private communication), and 8.2 per cent. in potash alum. Subsequently the alunite was analysed for water soluble potassium, acid soluble potassium (N/100 H_2SO_4), and total potassium (fusion with Na_2CO_3 and extraction with HCl); the values obtained were 4.75, 4.86, and 6.92 per cent. respectively.

One field and two pot experiments were done. In each case limiting nutrients other than potassium were supplied as follows:— 2.58 cwt sodium dihydrogen phosphate, 5 cwt calcium carbonate, 1 cwt magnesium sulphate, 7 lb copper sulphate, 7 lb zinc sulphate, 3.5 lb sodium borate, and 0.25 lb ammonium molybdate per acre. In the field trial *Trifolium repens* L. var. Irrigation white was used as the test plant. The pot culture experiments were conducted in a glasshouse on the closed pot system using *Trifolium repens* L. var. Irrigation white, *Medicago sativa* L. var. Hunter River Broadleaf, and *Phaseolus lathyroides* L. as the test species. Seed was inoculated with tested strains of *Rhizobium*, viz, strains SU295D, CB61 (originally Rothamsted AH2), and CB27 respectively. Five thousand grams of soil were used in the first experiment, and 1500 grams in the second. The insoluble compounds were mixed throughout the soil mass; potassium chloride and potash alum were supplied in solution. Rates of application were based on the amounts of potassium supplied in the dressings of potassium chloride.

Plant material was harvested by cutting the plants at ground level at first sign of flowering. The material was dried in a forced air oven at 60°C. Analyses for potassium were done by the flame photometer method.

Results and Discussion

First pot experiment 1955

The treatments and results are shown in Table 1.

All species showed visual symptoms of potassium deficiency when grown without added potassium. The symptoms of potassium deficiency for white clover and lucerne were similar to those described by Wallace (1951). Those for *Phaseolus* have been verified by water culture techniques in this laboratory; viz, reduced plant growth and development of rusty brown irregularly shaped areas on the lower leaves of the plant. These areas are shown on both sides of the leaf, but the affected tissue does not become necrotic until an advanced stage has been reached. The areas occur in the interveinal tissue in the vicinity of the mid rib and primary veins. In severe cases the edges of the affected leaves become chlorotic, followed by necrosis of both the leaf edges and the brown areas. Leaf abscission follows. The symptoms are seen on progressively younger leaves, but very rarely are the growing tips of the plant affected.

The addition of 0.50 g KCl per pot (equivalent to 1 cwt KCl per acre) produced normal healthy plants and gave a significant increase in yield. Doubling the rate of application had no further effect. In no case did additions of greensand or trachyte have any effect on either yields or deficiency symptoms. On the other hand additions of alunite and potash alum removed all symptoms of deficiency and gave

TABLE 1.

Effect of Potassium Compounls on Yield of Three Pasture Legumes—Pot Experiment* 1.

Treatments g/pot	≡ cwt/acre	Yield* White clover	Phaseolus	Lucerne
Nil		13.6	4.0	2.9
KCl 0.5	1.0	20.5	6.8	4.2
„ 1.0	2.0	21.4	6.4	4.0
Greensand 6.3	12.6	14.7	4.8	3.1
„ 12.6	25.2	15.9	5.0	3.9
Trachyte 4.5	9.0	13.3	4.3	2.9
„ 9.0	18.0	12.4	4.3	2.9
Alunite 4.5	9.0	20.0	6.8	5.3
„ 9.0	18.0	15.9	6.9	3.3
K. Alum 3.2	6.35	15.5	7.1	4.2
„ 6.4	12.7	15.9	6.1	2.4
Min. Sig. Diff. $P < 0.05$		2.9	1.4	1.1

*Means of 3 pots in g dry matter.

increased yields; however, yield increases varied with species.

With alunite, white clover and lucerne showed a significant increase in yield at the low level of application and no increase at the high level; yields of *Phaseolus* were significantly greater at both levels. With potash alum Phaseolus again showed significant increases in yields at both levels, lucerne only at the low level, and white clover at neither level of application. In every case in which increased yields were recorded they were of the order of those obtained from the additions of KCl equivalent to 1 cwt per acre.

The depressing effects of the high levels of alunite and potash alum on white clover and lucerne indicate some form of toxicity in these substances to the two species. *Phaseolus* is apparently tolerant to this toxicity. No symtoms of potassium deficiency were seen in the white clover and lucerne under these conditions. Both the affected species had reduced top growth and severely reduced root growth, the roots being dark and swollen. Alunite on thermal decomposition produces aluminium oxide and sulphur trioxide, but Bayliss and Koch (1955) state that in alunite from Western Australia evolution of sulphur trioxide does not commence below 650°C. The reduction in growth due to alunite calcined at 400°C may however still be due to the presence of free aluminium salts. The symptoms described are similar to those obtained by one of the authors (C.S.A.) in water culture in the presence of toxic levels of aluminium.

Second pot experiment 1956

Effect of calcining.—The alunite used in the first experiment had been calcined whereas the trachyte and other compounds had not. Fink, van Horn and Pazour (1931) have shown that the two primary reactions which occur during the thermal decomposition of pure alunite may be written as follows:—

$$2KAl_3(SO_4)_2(OH)_6 = 2KAl(SO_4)_2 + 2Al_2O_3 + 6H_2O \quad (1)$$

$$2KAl(SO_4)_2 = K_2SO_4 + Al_2O_3 + 3SO_3 \quad (2)$$

In these reactions, potassium compounds of greater solubility than alunite are released. It was decided therefore to carry out another experiment using calcinated trachyte at several rates, and restricting the species to the more sensitive white clover and lucerne. Trachyte contains micas, e.g. biotite, and feldspars, e.g. orthoclase, which are potassium aluminium silicates of more or less complexity. If potassium aluminium sulphates on heating can make potassium available to plants, the same might be true of potassium aluminium silicates. The trachyte was calcined at 350°-400°C for five hours. The treatments and results of this experiment are shown in Table 2. Two cuts from each species were made but as the difference between cuts was negligible, only the totals of the two cuts are shown.

Neither uncalcined nor calcined trachyte had any effect on plant growth; whereas the effect of alunite was equal to that of potassium chloride at each rate. This supports the results of the first experiment. It is possible that the calcining temperatures used were too low and that temperatures of at least 650°C may be required.

Field experiment 1956-57

To check the results obtained in pots, a trial with white clover was established in the field at Beerwah, Queensland. This was sown on July 13, 1956 in plots 15 x 15 links, 11 treatments, 5 replications in randomised blocks, and a 5 x 2 link quadrat cut per plot taken on March 13, 1957. A further quadrat was cut on September 17, 1957. Treatments and results are shown in Table 3.

In general the results of this trial are in agreement with those obtained from the pot trials.

TABLE 2.

Effect of Potassium Compounds on Yield of White Clover and Lucerne—Pot Experiment* 2.

Species	KCl equiv.† cwt/acre	Yield*			
		KCl	Alunite	Trachyte	
				Not Calcined	Calcined
White Clover	0	3.5	2.9	2.6	3.2
	0.25	5.3	6.0	3.3	3.3
	0.5	6.5	6.8	3.0	3.0
	0.75	7.9	7.9	3.2	3.1
	1.0	8.3	8.3	3.7	3.2
Lucerne	0	4.3	4.0	3.6	3.7
	0.25	5.9	5.5	3.6	4.0
	0.5	7.2	6.0	4.0	3.8
	0.75	7.4	6.5	3.9	3.9
	1.0	6.8	7.3	4.3	4.1

Min. Sig. Diff. P $<0.05 = 0.75$ g.

*Mean of three pots (two cuts each) in g dry matter.
†Trachyte and alunite taken as 9 cwt ≡ 1 cwt KCl.

TABLE 3.

Effect of Potassium Compounds on Yield and Potassium Content of Trifolium repens (Field Trial at Beerwah).*

Treatment		Yield* March 1957	Yield* September 1957	% K March cut
Nil		7.5	7.6	0.50
KCl (Original dressing only)	0.5 cwt/acre	9.9	9.7	0.88
KCl („ „ „)	1.0 „ „	12.0	10.8	1.15
KCl (Additional dressing)	0.5 „ „	12.4	12.2	—
KCl („ „)	1.0 „ „	11.0	13.3	—
Trachyte	4.5 „ „	6.7	7.2	0.71
Trachyte	9.0 „ „	8.9	9.3	0.68
Trachyte (calcined)	4.5 „ „	8.2	5.4	0.41
Trachyte („)	9.0 „ „	8.2	8.4	0.57
Alunite	4.5 „ „	11.1	9.5	1.05
Alunite	9.0 „ „	11.6	9.2	1.18
Min. sig. diff. $P < 0.05$		3.5	4.0	

*Mean of 5 plots in cwt per acre dry matter.

Effect of time.—It was thought that time might be a factor in the release of potassium from the trachyte and greensand. Pots from the first experiment, which were stored dry after the end of the first growing season, were replanted the following year, with the addition of nutrients other than potassium. Yields of plant material obtained did not indicate any release of potassium from trachyte or greensand, and plants grown in pots receiving these treatments had visual symptoms of severe potassium deficiency. These results are not presented.

In the field experiment no benefit from either form of trachyte was observed in the second season, (September 1957). In fact yield increases occurred in the second year only where renewed applications of potassium chloride were made after the first harvest (Table 3).

Conclusions

On such light soils as the Beerwah sand, deficiencies of potassium are not likely to be corrected by the application of either greensand or trachyte. Neither fine grinding nor calcining at 400°C, both expensive processes, were of avail. Potash alum was effective with lucerne and *Phaseolus lathyroides* but not with white clover.

Calcinated alunite was equal in effect in the first year to potassium chloride. This effect did not extend into the second year so that additional applications would be needed for long term benefit. Equally however, repeated additions of potassium chloride are also required on this soil. Heavy costs of transport are involved with this material, but these might be warranted should overseas supplies of potassium be cut off.

The aluminium content is another disability, and this might be accentuated with repeated dressings. However, if the depressing effect of high applications of alunite is indeed due to aluminium, then in view of the work of Schmehl, Peech and Bradfield (1952) this effect may not be significant on soils with greater exchange capacity than the Beerwah soil, which has an extremely low exchange capacity. The further possibility exists that a new and economic method of removing the aluminium from alunite might be found and a relatively pure form of potassium sulphate result.

The differences in response of the test species to potash alum and calcinated alunite were marked. All three species responded to low dressings of alunite, but only *Phaseolus lathyroides* to a higher application. Much the same pattern was followed with potash alum, except that in this case white clover did not respond to either rate of application. These findings lend still further support to Norris' (1956) contention that the responses to soil factors of members of the tribe *Trifolieae* cannot be taken for granted as being typical of all members of the *Leguminosae*. It is perhaps not surprising to find a tropical legume showing tolerance to levels of aluminium that adversely affect temperate species, since highly leached tropical and sub-tropical soils commonly have higher levels of aluminium than many temperate soils.

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The Use of an Anthocyanin-rich Variety of Barrel Medic, *Medicago tribuloides* Desr., for Prompt Assessment of Strain Effectiveness in *Rhizobium meliloti*

J. A. BROCKWELL

A technique is described for making an early visual evaluation of effectiveness of strains of Rhizobium meliloti. It is based upon the disappearance of red pigmentation from the foliage of an anthocyanin-rich variety of Medicago tribuloides Desr. when that plant is nodulated by an effective strain of nodule bacteria. This technique made it possible to distinguish significant colour differences between highly effectively and ineffectively nodulated seedlings sixteen days after their inoculation.

For many years the conventional method of assessing the effectiveness of a legume/*Rhizobium* symbiosis has been to grow plants and bacteria in association in a sterile agar, liquid or sand culture medium with adequate replication, and, after a period, to harvest the foliage or the whole plants, dry them and obtain the results in terms of weight or nitrogen content. Lately, however, for various purposes, several other reliable techniques have been devised.

Wieringa and Bakhuis (1957), Wrobel (1956), and Jordan and Garrard (1951) were able to shorten the test period using a variety of techniques. Brockwell (1956) utilized the Red Leaf strain of subterranean clover (*Trifolium subterraneum* L.) as an indicator plant for evaluating effectiveness in *Rhizobium trifolii*. This technique was based upon the disappearance of anthocyanin pigmentation from the leaves of the plant when it was effectively nodulated and made it possible, within eighteen days of inoculation, to distinguish visually significant differences between effective and ineffective nodulation. The present paper reports the adaptation of the technique to the determination of effectiveness of nitrogen fixation by strains of *Rhizobium meliloti*.

Materials and Methods

In general the methods adopted in the previous work (Brockwell 1956) were used or modified. Three anthocyanin-rich barrel medic (*Medicago tribuloides* Desr.) varieties, whose leaves under normal field conditions were almost wholly pigmented red, were obtained and grown in a nitrogen-free medium. The variety, 398B, which appeared richest in anthocyanin (its leaves pigmented most quickly in the absence of nitrogen) was selected for further investigation.

Plants were grown in 6 in. x ¾ in. test tubes under bacteriologically-controlled conditions

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using the technique first described by Thornton (1930). Seeds of equal size (210 per g) were sown on nitrogen-free agar slopes and their dormancy broken by cold treatment as before (Brockwell 1956). After germination the plants were grown in a glasshouse under a 15 hr per day fluorescent illumination giving approx. 1500 f.c. outside the test tubes. (Obtained from 9 four ft. long Philips T.L.F. lamps). Preliminary experiments indicated that these light conditions were within the optimum range for the purpose; low intensities delayed appearance of pigmentation while high levels appeared to inhibit nitrogen fixation—whether the latter was due to a light or to a heat effect was not determined. During the period of growth the means of the daily maximum and minimum temperatures within the tubes were approx. 69°F and 53°F respectively; the absolute maximum and minimum were 77°F and 48°F.

It was known (Brockwell 1956) that colour differences between clover plants nodulated with strains of bacteria of different effectiveness could be expected earliest where nodulation occurred with the least delay after germination. It was assumed that barrel medic would behave similarly and to reduce this delay to a minimum, a preplanting technique was employed (Nutman 1953, 1957) which reduced time to nodulation from 13 days to 11 days from inoculation. One uninoculated plant of *M. tribuloides* var. 173 was grown in each tube for 10 days and removed before sowing the test seeds.

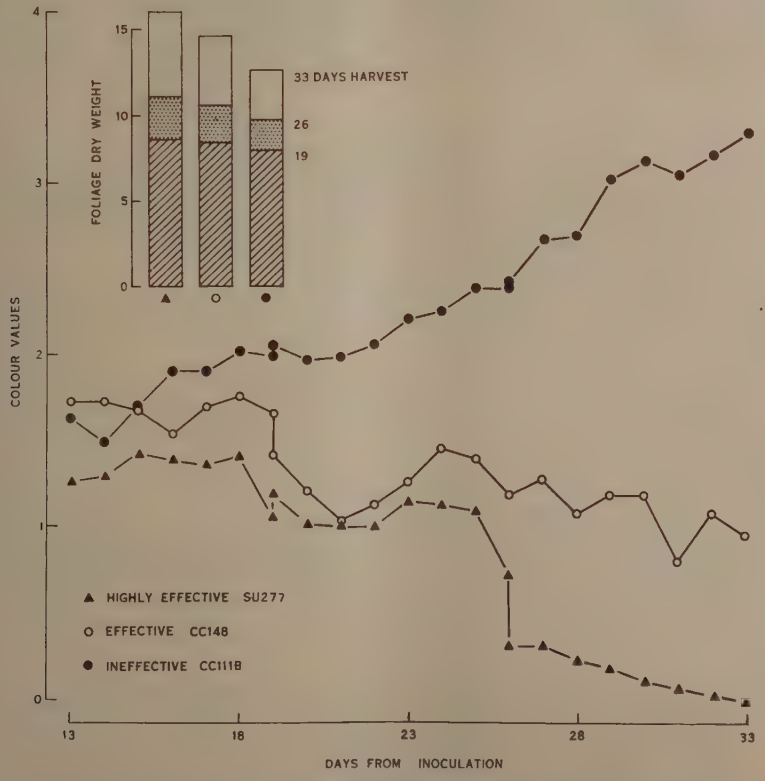

Figure 1.—Daily trends of unifoliolate leaf pigmentation, and foliage weights of plants harvested at 19, at 26, and at 33 days from inoculation. Mean time between inoculation and nodulation: SU277—11.3 days, CC148—10.2 days, CC111B—11.0 days.

Sterilised test seed was inoculated by a 5 minute immersion in a suspension of a 5 day old culture of *Rh. meliloti*. The strains used were SU277—highly effective, CC148—also effective but not as good as SU277, and CC111B—ineffective. Forty plants were inoculated with each strain and the tubes were arranged at random in six blocks. Observations were made daily to determine the time between inoculation and the appearance of the first nodule, and to rate, using the scale 0.0—0.5—1.0—1.5— . . . —4.0, the proportion of the upper surface of the unifoliolate leaf that was pigmented red. About one third of the plants in each treatment were harvested at 19, 26, and 33 days and the top growth oven-dried and weighed.

Results

The daily trends of the visual estimates of unifoliolate leaf pigmentation are illustrated in Fig. 1. The statistical analyses of these indicated that the relation between the replicate variance and the mean was not symmetrical about the mid-point of the potential colour range, the point of maximum variability lying close to a mean rating of 1.0. A curvilinear trend was fitted to the data by hand with a check that the totals of the estimated variances from the curve and the actual variances agreed. Assuming that this relation of variance and mean will hold generally one can determine the minimum number of samples to show differences between strains with specified mean colour ratings at the 5 per cent. and 1 per cent. levels with a probability of 0.5. This has been done and the figures for the comparisons between the strains of *Rh. meliloti* used in this work are presented in Table 1.

The data indicated that 16 days after inoculation, 27 replicates were required to establish differences between the highly effective and the ineffective strains at the 5 per cent. level of significance; on the sixteenth day 40 replicates of each treatment were available for rating. Correspondingly, significant pigmenta-

TABLE 1.

The colour of unifoliolate leaves of plants inoculated with highly effective, effective and ineffective strains of Rh. meliloti and the number of replicates required to determine significant differences between treatments.

Inoculum		Mean leaf colour values at intervals between 16-33 days from inoculation							
		40 plants			27 plants			13 plants	
		16	18	20	22	24	27	30	33
Highly effective—SU277		1.39	1.41	1.02	1.00	1.13	0.31	0.12	0.00
Effective—CC148		1.55	1.77	1.21	1.13	1.46	1.23	1.19	0.96
Ineffective—CC111B		1.87	2.03	1.98	2.07	2.26	2.68	3.14	3.32
Comparison	Level of significance	Approx. number of replicates required for significant differences at intervals between 16-33 days from inoculation							
SU277 *v.* CC111B	P = 0.5	27	21	10	7	7	1	1	1
	P = 0.1	46	35	16	13	12	2	1	1
CC148 *v.* CC111B	P = 0.5	50	98	15	10	13	4	2	1
	P = 0.1	83	167	24	17	23	6	3	2
SU277 *v.* CC148	P = 0.5	257	63	228	358	72	10	5	5
	P = 0.1	435	108	385	625	125	17	8	9

tion differences appeared between plants inoculated with strains CC148 and CC111B on the twentieth day. Where the difference in nitrogen fixing abilities of the strains was relatively small (viz. SU277 *v.* CC148) significant colour differences were first established 27 days after inoculation.

The removal at intervals of plants for the purpose of obtaining dry weights has meant in some cases that mean colour values differ considerably before and after sampling. This is particularly so for the CC148 treatment at the first sampling date and for SU277 on the second, and provides the explanation of the abrupt changes following sampling in the amount of replication required to show significant differences between these two treatments (Table 1).

In a like manner, assuming that the sample variances for the weights of plants harvested after different durations (also illustrated in Figure 1) are reliable estimates of the population variance, one can also determine the number of replicates to show significance at the 5 per cent. and 1 per cent. levels using plant dry weight as the criterion. The weight of foliage and the colour ratings at each date of harvest together with their relative efficiencies for determination of strain effectiveness are compared in Table 2. Where large differences in nitrogen fixation are being sought (SU277 or CC148 *v.* CC111B) colour rating is consistently more sensitive as an indicator of strain effectiveness than foliage weight. While this is not so for the comparison between SU277 and CC148, colour is still the more accurate criterion for nitrogen fixation 33 days after inoculation.

Discussion

Using the method described above with forty replicates of each treatment it has been possible to detect significant differences between

TABLE 2.

Comparison of mean dry weight and leaf colour values as estimates of effectiveness in M. tribuloides var. 398*B at* 19, 26 *and* 33 *days from inoculation.*

Inoculum	19 days		26 days		33 days	
	Dry wt. (13 plants) (mg)	Leaf colour (40 plants) (0-4)	Dry wt. (14 plants) (mg)	Leaf colour (27 plants) (0-4)	Dry wt. (13 plants) (mg)	Leaf colour (13 plants) (0-4)
Highly effective—SU277	8.56	1.06	11.16	0.73	16.01	0.00
Effective—CC148	8.39	1.67	10.58	1.19	14.66	0.96
Ineffective—CC111B	7.94	2.00	9.71	2.35	12.61	3.32

Comparison	Level of significance	No. of replicates required for significant difference using criteria of colour and dry weight.					
		19 days		26 days		33 days	
		Dry wt.	Colour	Dry wt.	Colour	Dry wt.	Colour
SU277 *v.* CC111B	P = 0.5	15	10	4	3	1	1
	P = 0.5	26	16	7	5	2	1
CC148 *v.* CC111B	P = 0.5	57	66	22	5	5	1
	P = 0.1	98	115	39	10	8	2
SU277 *v.* CC148	P = 0.1	89	24	26	44	7	5
	P = 0.1	153	41	46	75	12	9

amounts of pigmentation in the unifoliolate leaves of effectively and ineffectively nodulated seedlings sixteen days after inoculation or five to six days after nodulation. With only ten replicates differences significant at the 5 per cent. level were obtained three days later. At an early stage of plant development the technique is more sensitive than the standard one of harvesting and weighing the foliage.

It seems pertinent to compare the efficacy of this technique with that of the similar method for assessing strain effectiveness in *Rh. trifolii* (Brockwell 1956). In the case of *Rh. trifolii* and the appropriate indicator plant, Red Leaf subterranean clover, the accuracy of the colour criterion in relation to the weight is more pronounced than with *Rh. meliloti* and barrel medic variety 398B. An examination of the data presented in the previous paper (Brockwell 1956) reveals that, between the sixteenth and the twenty-third days from inoculation, the mean colour values of the effectively nodulated clover fell from 2.5 to 1.3 while the colour values of the clover with ineffective nodules rose from 3.1 to 3.6, the combined difference being 43 per cent. of the potential colour range. For the same period of the experimentation with barrel medic and *Rh. meliloti* described here the colour values for the highly effective symbiosis fell from 1.4 to 1.2 while those for the ineffective association rose from 1.9 to 2.2, a total difference of only 13 per cent. of the potential colour range. This suggests that, where the disappearance of anthocyanin pigmentation is concerned, Red Leaf subterranean clover responds more quickly to the onset of nitrogen fixation than barrel medic variety 398B and may account for the greater sensitivity of the clover as an indicator of effective nodulation.

In association with strains of nodule bacteria representing broad categories of effectiveness, the variety 398B appears to differ very little from other varieties of *M. tribuloides* (Brockwell, unpublished data) and could, therefore, be used as an indicator plant for determining effectiveness of *Rh. meliloti* for barrel medic generally. Furthermore certain strains of *Rh. meliloti* are effective in fixing nitrogen for lucerne (*Medicago sativa* L.) and Bokhara clover (*Melilotus alba* Desr.) as well as barrel medic. Some such strains are used in Australia for preparation of considerable quantities of commercial inoculant for these species and the technique would be well suited for testing samples of these products.

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Technical Notes

Manganese Excess and Bark Necrosis in Pears

Josephine pears growing at the Research Station, Tatura, in the Goulburn Valley, on grey clay loam, overlying grey medium to heavy clay are suffering from "papery bark", an internal bark necrosis, with a cracking of the outer bark of shoots and limbs and rolling of the bark cuticle. This disorder is occasionally seen on Josephine pears throughout the Goulburn Valley area.

The pH of the soil where these trees are growing (Site No. 1) is low, with average for 0-6 in. depth 5.2 and for 6-12 in. depth 5.7 and with the lowest figure 4.3. The affected orchard is naturally low lying and the soil can be waterlogged for extended periods in any wet winter. As the availability of soil manganese increases with increasing soil acidity, and in strongly acid soils manganese is frequently present in toxic concentrations (Wallace 1951) and anaerobic conditions resulting from waterlogging of the soil could have increased the amount of divalent manganese (Leeper 1947) it was presumed that there was an excess uptake of manganese by the pear trees, resulting in toxic effects in the bark.

Josephine pear trees growing on the adjacent property (Site No. 2) on slightly acid, brown loam, overlying a medium clay, were free of papery bark symptoms and presented a healthy appearance. The pH of this soil for 0-6 in. depth was 5.7 and for 6-12 in. depth 5.6 and the lowest figure 5.0, and prolonged water-logging would be very unlikely.

Leaves, buds and bark from Josephine pear trees with "papery bark" symptoms (Site No. 1) and from those without symptoms (Site No. 2) were sampled and manganese content determined.

Methods of Analysis

A modified D. J. D. Nicholas (1953) method of chemical tissue tests for excess manganese was used.

Results

Number of samples and manganese content are set out in Table 1, and show a low level of extractable manganese ranging from 0 to 5 p.p.m. in fresh leaves of healthy Josephine pear trees and a moderately high level of this element in the leaves of pear trees showing papery bark symptoms. More than 40 per cent of 54 tested samples of papery bark trees are in the range over 15 p.p.m. of manganese.

The severity of the papery bark symptoms appeared to be correlated with the amount of extractable manganese in the leaves. Two limbs of a Josephine pear tree at Site No. 1, one healthy, and the other showing papery bark symptoms, were sampled and manganese content in the leaves determined. The results are shown in Table 2.

TABLE 1.

Manganese content of Josephine pear leaves related to symptoms of "papery bark", sampled—(1956/57).

Location	Symptoms	Number of Samples with extractable manganese p.p.m. in fresh leaves, as tabulated.				
		0-5 ppm.	5-10 ppm.	10-15 ppm.	15-20 ppm.	>20 ppm.
Site No. 1	Papery Bark	5	12	15	20	2
Site No. 2	Healthy	12	—	—	—	—

TABLE 2.

Manganese content of fresh Josephine pear leaves from two limbs of one tree (Site No. 1), related to severity of the papery bark symptoms.

Location of the sampled limb.	Symptoms	Extractable Manganese p.p.m. in fresh leaves.
West	Healthy	5
South	Papery Bark	23

In winter 1957, during the dormant stage of the trees, buds and bark of healthy trees and of papery bark affected trees were sampled and extractable manganese determined. The results are shown in Table 3.

As Table 3 shows, high amounts of extractable manganese accumulate in buds and bark of Josephine pear trees showing papery bark symptoms and a low amount of this element is found in tree parts without these symptoms.

Injection of Manganese

To check the presumption that excess uptake of manganese results in development of papery bark disorders, a healthy Josephine pear tree (approximately 26 years old) on site No. 3 was selected for trial. This tree is growing on slightly acid, grey-brown clay loam, overlying grey-brown neutral to alkaline medium to heavy clay. The mean pH of this soil is 5.4 for 0-6 in. depth, 6.3 for 6-12 in. depth, 7.6 for 12-24 in. depth and 8.8 for 24-36 in. depth, with the lowest figure 5.2 in the 0-6 in. depth.

Manganese sulphate in No. 00 gelatine capsules which contained 1.1 g of the salt, was injected into 3-4 cm deep holes and a cork stopper inserted afterwards. Two limbs, N.W. limb and S.W. limb, of this tree were used.

The effect of the manganese injection in S.W. limb is shown in Table 4.

The survey of the injected limb showed some light to heavy damage to the fruit, with cracking and blackening of the skin. An analysis of the damaged skin showed up to 103 p.p.m. extractable manganese in the fresh samples. The manganese content of the skin of a healthy fruit was only 1 p.p.m.

The first trace of symptoms of papery bark disorders on the S.W. limb showed up, approximately three months after the first manganese sulphate injection.

Discussion

The survey of the limbs showed that after manganese sulphate injection the health of the limbs gradually declined. The incidence of a disorder known locally as leaf spotting also seemed to increase with high manganese. Some leaves on the injected limb developed marginal scorch, which was more severe on those from the top of the limb. These disorders were first noticed on January 8, 1958, and were more severe on S.W. and less severe on N.W. limb. On February 2, 1958, some fruit on S.W. limb showed blackening and cracking. The figures for extractable manganese increased in the damaged fruit skins in comparison with unaffected ones.

TABLE 3.

Manganese content in fresh plant parts ex site No. 1 and site No. 2 from papery bark affected and healthy trees respectively.

	Extractable Manganese p.p.m. of fresh weight			
	Ex site No. 1 with "papery bark" symptoms		Ex site No. 2 with healthy appearance.	
Plant Parts	Number of samples	Mn.p.p.m.	Number of samples	Mn.p.p.m.
Buds	4	11	4	2
Bark	8	12	6	2

TABLE 4.

Effects of injecting manganese sulphate into the S.W. limb of Josephine pear tree at site No. 3.

Date of sampling	Date of injection	G of manganese sulphate injected	Symptoms of papery bark	Extractable Mn p.p.m. in fresh leaves	No of samples
5/11/57			None	2	1
	11/11/57	5.5	,,		
22/11/57			,,	17	5
	22/11/57	4.4	,,		
25/11/57			,,	10	2
3/12/57			,,	10	2
5/12/57			,,	6	1
	5/12/57	6.6	,,		
10/12/57			,,	13	1
18/12/57			,,	24	2
	18/12/57	4.4	,,		
8/1/58			,,	100	2
10/2/58			Trace	97	2
11/3/58			Slight	116	2
11/4/58			Moderate	42	2

The distribution of the injected manganese compound through the limb was uneven. Some leaves absorbed very high amounts (up to 180 p.p.m.) of the injected element, and showed severe marginal scorch symptoms. Other leaves on the same sampling date gave only 14 p.p.m. manganese content.

Repeated manganese sulphate injections were necessary to maintain high levels of this element in leaves, due to wider distribution of the injected compound in the tree.

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Manganese Excess and Bark Necrosis in Apples

Some Delicious apples growing at Tongala in the Goulburn Valley on neutral to slightly acid brown loam overlying medium to heavy clay, are showing "Measles", an internal bark necrosis with elevations scattered over the surface of bark of one year old and older shoots, presence of brown necrotic areas in the bark beneath the elevated pustules and a roughened appearance, sometimes with a cracking of the outer bark on older twigs and limbs.

L. M. Shannon (1954) showed that internal bark necrosis could result from boron deficiency, manganese toxicity, abnormal iron or combined factors. The possibility of manganese toxicity was investigated and manganese was determined in leaves of sick and healthy trees, using a modified D. J. D. Nicholas (1953) method.

Results of Analysis

The average manganese extractable in Morgan's reagent in p.p.m. in fresh leaves of a number of trees is shown in Table 1. These trees showed symptoms varying from severe measles to normal health, as indicated.

TABLE 1.

Manganese content of Delicious apple leaves related to symptoms of measles.

Tree	Symptoms	Extractable manganese p.p.m. in fresh leaves.	Number of samples
A	Healthy	3	5
B	,,	3	2
C	,,	3	4
D	Measles	12	4
E	,,	16	3
F	,,	16	1
G	Mild Measles	5	3
G	Severe Measles	23	5
H	,, ,,	36	3

These results show that low manganese occurs in the leaves of healthy trees and a moderate to high level in the leaves from limbs showing "measles". The severity of the symptoms appeared to be positively correlated with the amounts of manganese in fresh leaves. Tree G shows severe measles on one limb and mild measles on all other limbs and the amount of extractable manganese in the leaves of these limbs is 23 and 5 p.p.m. respectively.

As the soil in the affected orchard is neutral to slightly acid (pH of 0-6 inch depth was 6.3-7.0) the excess uptake of manganese is unlikely to be due to soil acidity (Wallace 1951). It is suspected that anaerobic conditions resulting from water-logging of the soil greatly increased the amount of divalent manganese (Leeper 1947) resulting in an excessive uptake of this element. The affected part of the orchard was continuously flooded for up to six months in the abnormally wet winter of 1956. The symptoms of the measles disorder were first noticed in January 1957.

Injection of Manganese

Two healthy five year old Delicious apple trees in the same orchard were selected for trial. Manganese sulphate in No. 00 gelatine capsules (each containing 1.1 g) was injected in holes 3 cm deep and a cork stopper inserted afterwards. One limb only from each tree was used. The effect of the manganese injections on a typical tree is shown in Table 2.

Discussion

The distribution of manganese in the injected limbs was uneven and some leaves absorbed very high amounts. This resulted in complete scorching of the leaf. Determination of extractable manganese in scorched leaves showed 200-500 p.p.m. of this element. This may indicate that approximately 200 p.p.m. of extractable manganese in fresh leaves is the upper limit without obvious heavy damage.

Repeated injections were necessary to maintain high toxic levels of manganese in leaves, due to wider distribution of the injected compound in the tree. The first symptoms of measles appeared 51 days after the manganese sulphate injection.

TABLE 2.

Effects of injecting manganese sulphate into a limb of the Delicious apple tree, at Tongala, 1957/58.

Date of sampling	Date of injections	Gr. of manganese sulphate injected	Severity of measles	Mean Extractable Manganese p.p.m. in fresh leaves	Number of samples
15/11/57			Healthy	2	1
	15/11/57	2.2	,,		
28/11/57			,,	294	2
4/12/57			,,	25	1
9/12/57			,,	4	1
17/12/57			,,	7	2
	17/12/57	1.1	,,		
7/1/58			Trace	14	2
23/1/58			Moderate	9	2
5/2/58			Heavy	15	2
	5/2/58	1.1	,,		
26/2/58			,,	16	1

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A Rapid Method for Determining Suncracking in Rice

Suncracking in rice is the development of a cleavage plane, or planes, within the endosperm of the caryopsis. Beginning as a weakness in the centre of the grain, fractures develop radially to the periphery (Henderson 1954).

The phenomenon is of considerable economic importance to the rice industry as grains with sufficiently well developed cracks will break during the milling process. Breakage rates up to 40 per cent. have been recorded in Caloro rice. Suncracked headrice is also liable to shatter on exposure to sunlight or sudden fluctuations in temperature and humidity.

To establish the basic causes of suncracking it is necessary to recognise the initial stages of its development. The standard milling test (U.S.A.M.S. 1941) has previously been used to assess the amount of damage due to suncracking but has the following disadvantages:—

1. All suncracked grains do not break during milling.

2. Uncracked grains may be broken mechanically.

Techniques to measure the number of grains suncracked have been developed by Kik (1951) who examined kernels on the stage of a stereoscopic microscope using transmitted light and by Milner *et al.* (1952) who demonstrated the usefulness of radiography in detecting physical anomalies in cereal grains. Henderson (1954) published photomicrographic evidence of conditions within the suncracked rice kernel. Hogan *et al.* (1954) used a combination of the two last mentioned techniques.

While each of these methods is extremely useful for the specific purpose for which it was designed, none is completely suited to the large scale survey work which is an integral part of the rice research at Yanco Experiment Farm. A simple, rapid technique using readily available, inexpensive apparatus has been developed to meet this particular requirement.

Method

The apparatus as shown in Figure 1 is essentially a plane silver backed glass mirror onto which a beam of light is directed at an angle of approximately 10 to 15°. One hundred randomly selected grains are dehulled in a McGill sheller and placed on the mirror surface. Examinations are made from above and to one side so that the grains and their mirror images are visible.

The fractures, which appear as the margin between unequally illuminated portions of the grain, are most easily observed when the longitudinal axis of the grain lies parallel to the light beam. Careful orientation of the grain in relation to the light source is only necessary where cracks are not fully developed, as under normal conditions they can be seen in whatever position the grain lies.

Where cracks are not sufficiently developed to be immediately recognisable the grain is rotated about the minor axis. A further check can be made by examining the grain in a stronger beam of transmitted light.

Light coming from the reflecting plane of the mirror onto the undersurface of the grain gives maximum contrast between the endosperm portion on either side of the fracture.

Discussion

It is considered that the examination of grains could be further facilitated by the incorporation of a condenser to concentrate light onto single grains where required.

Figure 1.

The disadvantages of the technique are that:—

1. Only dehulled grains can be examined.
2. Chalky and very immature grains cannot be accurately classified.
3. Glutinous varieties are difficult to evaluate.

The accuracy and rapidity with which samples can be rated and the simplicity of the equipment involved make the technique of considerable value to the rice research programme.

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A Least Cost Feed for Laying Hens Using Linear Programming

Efficient feeding plays a major role in profitable egg production. In a survey of commercial egg producers by the Bureau of Agricultural Economics (1955) feed costs for 18 poultry farmers in Western Australia amounted to 89 per cent. of their total cash costs. The most profitable feed is one which gives the greatest number of eggs of first quality for the least feed expenditure. Within the limits of the laying potential of a fowl, the number of eggs laid depends largely upon the quality and quantity of the feed supplied.

Poultry farmers therefore require a feed which will meet specified minimum nutrient requirements at least cost. Such specifications will vary with the purpose in hand. The nutritional requirements of poultry in Western Australia have been given by Morris (1950). In this study Morris also suggested several alternative rations for the various requirements. He gave little attention, however, to the problem of the least cost ration.

The usual approach for formulating a least cost ration is by trial and error, or by comparative costing of various nutrient concentrates and combining the cheapest of each. A more systematic method involves the use of simultaneous equations (Geddes, 1942) but the solution requires as many feed constituents as there are nutrient requirements. Linear programming provides a systematic way of finding the unique least cost ration.

An example is given here of the use of the simplex solution of linear programming in finding a least cost ration for laying hens. Minimum nutrient requirements and the analysis of Western Australian feedstuffs are taken mainly from Morris (1950), and are supplemented from other sources. The nutrient contents and approximate prices (June, 1957) of these feedstuffs, together with the nutrient requirements for laying hens, are given in Table 1. We assume that the nutritive ratio* of the final ration is the weighted average of

*The nutritive ratio is the ratio of available energy to available protein.

TABLE 1.

Nutrient content and price of selected feedstuffs.

Feed	Price per 100 lb (Pence)	% Crude protein	% Calcium	% Phosphorus	Nutritive ratio
Wheat	285	10	0.04	0.22	7.1
Oats	315	9	0.05	0.22	6.6
Barley	330	10	0.04	0.22	5.6
Wheat bran	246	14	0.07	0.60	4.3
Wheat pollard	246	13.5	0.05	0.32	4.3
Meatmeal	482	50	8.0	4.0	0.5
Skim-milk	1393	37	0.13	0.11	1.5
Dried buttermilk	1393	30	1.3	0.8	1.6
Oyster-flour	117		38.0		
Bonemeal	250	20	20.0	12.0	0.3
Requirement		15	2.5	1.0	4.5

the nutritive ratios of the component feedstuffs, and can therefore be treated as the other nutrients.

To minimise the computational burden in reaching a solution, the various feedstuffs were examined with a view to deleting those which were obviously inefficient for all nutrient requirements. For this purpose a modification of a technique given by Boles (1956) was used.

The data of Table 1 were then expressed in terms of the cost of each feed needed to reach the minimum requirement for each nutrient per 100 lb of feed ration, i.e.,

$$\text{N.R.} = \frac{\text{Digestible carbohydrate} + 2.5 \times \text{digestible fat}}{\text{Digestible protein}}$$

$$d_{ij} = \frac{b_j c_i}{a_{ij}},$$

where d_{ij} is the cost of each feed such that the requirement of nutrient j, b_j, is met a_{ij} is the content of nutrient j in 100 lb of feedstuff i, and c_i is the price in pence per 100 lb of feedstuff i. The d_{ij} are given in Table 2, where blanks indicate infinity. Inefficient feedstuffs for all nutrients were found by comparing pairs of rows in Table 2. If for any pair of rows the elements of one row are all larger than or equal to the corresponding elements of the other row, then the first feedstuff is inefficient for all nutrients and can be deleted. (A feedstuff can also be tested for inefficiency against a linear combination of the respective d_{ij} terms for two or more other feedstuffs where the sum of the coefficients of combination equals unity.) Barley, pollard, skim-milk, and buttermilk were deleted from further analysis on the basis of this preliminary test.

TABLE 2.

Cost in pence of quantity of selected feedstuffs necessary to supply minimum requirement for each nutrient.

Feed	Crude protein	Calcium	Phosphorus	Nutritive ratio
Wheat	428	17,813	1,295	181
Oats	525	15,750	1,432	215
Barley	495	20,625	1,500	265
Wheat bran	264	8,786	410	257
Wheat pollard	273	12,300	769	257
Meatmeal	145	151	121	4,338
Skim-milk	565	26,788	12,664	4,179
Dried buttermilk	697	2,679	1,741	3,918
Oyster-flour		8		
Bonemeal	188	31	21	3,750

The model was solved by the simplex method adapted to allow for minimum specifications rather than maximum specifications (Katzman, 1956). Feedstuffs were tabulated in the normal way as activities x_1 to x_6. To allow for the fact that some nutrients in the final ration might be in over-supply, the coefficients of the slack activities x_7 to x_{10} were negative. In view of this fact a further set of artificial activities, x_{11} to x_{14}, was added to

TABLE 3.

The first tableaux of the simplex worksheet.

				M	M	M	M		285	315	246	482		117	250						
										Wheat	Oats	Bran	Meat meal			Oyster Bone flour meal					
		x_0	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}		x_1	x_2	x_3	x_4		x_5	x_6	x_7	x_8	x_9	x_{10}
M	Crude protein	x_{11}	15.0	1					10.0	9.0	14.0	50.0			20.0	−1			
M	Calcium	x_{12}	2.5		1				0.04	0.05	0.07	8.0		38	20.0		−1		
M	Phosphorus	x_{13}	1.0			1			0.22	0.22	0.60	4.0			12.0			−1	
M	Nutritive ratio	x_{14}	4.5				1		7.1	6.6	4.3	0.5			0.3				−1
M	Weight	x_{15}	100.0					1	100	100	100	100		100	100				
		z		M	M	M	M	M	+	+	+	+		+	+	- M	−M	-M	−M
		z − c							±285	±315	±246	±485		±117	±250	−M	−M	−M	−M

serve as an artificial basis. In order that the final ration be of the correct weight (100 lb.) a weight requirement was added. This necessitated the addition of a further artificial activity, x_{15}. Since the aim was to minimise cost subject to certain requirements, the activity with the largest *positive* z_j-c_j value was selected to go into each iteration. To prevent any of the artificial activities from reappearing in the basis, large positive values, + M, were assigned to each, thus assuring that their z_j-c_j values would never be positive. The first tableau of the simplex worksheet is shown in Table 3.

The final least cost ration consisted of:—

1.

28 lb wheat
4 lb meatmeal
11 lb bonemeal
57 lb bran

100 lb ration

This ration (apart from errors of rounding to the nearest pound) contained 15 per cent. protein, 2.5 per cent. calcium, 1.85 per cent. phosphorus, and a nutritive ratio of 4.5, thus fulfilling the minimum requirements with 0.85 per cent. phosphorus to spare. The total cost of this ration was slightly under 22s. 3d.

This ration might be deficient in terms of palatabilty, protein quality, etc. For example, the calcium to phosphorus ratio in this ration is 1.4 as against a ratio of 2.25 as recommended by Morris. The penultimate tableau of the simplex worksheet, however, specified the least cost ration which fulfilled the nutrient and weight requirements without any nutrient being available in excess supply. This ration consisted of:—

2.

25 lb. wheat
4 lb. oyster-flour
7 lb. meatmeal
2 lb. bonemeal
62 lb. bran

100 lb. ration

TABLE 4.

Comparison of Morris's standard rations and least cost rations derived by linear programming.

Ingredients	Morris's Rations 1. lb	2. lb	3. lb	4. lb	5.	Programmed Rations 1. lb	2. lb	3. lb
Bran	30	20	10	30		57	62	47
Pollard		10	10	30				
Crushed wheat	42	37	50	15	80	28	25	34
Gristed oats	20	20	20	15				
Meatmeal	10	11	13	8	15	4	7	16
Buttermilk	2							
Bonemeal	3	3	3	3	2	11	2	
Oyster flour	3	3	2	3	2		4	3
Total	110	104	108	104	89	100	100	100
Cost (pence per 100 lbs.	312	294	303	276	346	267	267	293

The total cost of this ration was slightly over 22s. 3d. i.e. scarcely different from the cost of ration 1, which allowed for nutrient over-supply. It is not general, however, that rations which do and do not allow for excess nutrient supply result in minimum costs which are so similar.

Care must be taken in selecting the original feed-stuffs for consideration. For example, meatmeal can be considered as a concentrate for both crude protein and phosphorus. On this basis bonemeal was excluded from consideration and a further linear programming analysis was made. (In this case buttermilk was not inefficient in the preliminary test, and was included in the simplex worksheet.) The resulting least cost ration consisted of:—

3.

34 lb. wheat
16 lb. meatmeal
3 lb. oyster-flour
47 lb. bran

100 lb. ration.

The ration fulfilled the minimum requirements with 3 per cent. protein to spare, i.e., 18 per cent. protein. The total cost of this ration was raised to 24s. 5d. Bonemeal is a more efficient source of phosphorus than meatmeal (by the d_{ij} criterion), and if it is used meatmeal can be introduced primarily to supply protein, for which it is the most efficient source. It is important to try to find the most efficient source of each nutrient, but, as for calcium in ration 1, the most efficient source of a nutrient may not be included in the final ration.

The least cost ration obtained will obviously vary with feedstuff costs. At the prices used in this analysis, comparisons of five rations given by Morris and the three rations obtained from this example, are given in Table 4.

The nutrients selected for this example are not the only ones necessary for adequate nutrition. It might be necessary to add vitamin and mineral requirements not considered in this example. Many of these limitations, however, including factors of palatability, protein quality, maximum fibre content, etc., could themselves be treated by linear programming analysis. But if this were not feasible nor worthwhile, the ration would still present the least cost feed mixture which could serve as an appropriate basis for subsequent modification.

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Supplying Urea to Stock through Drinking Water

Widespread interest is being shown in the possibility of using urea as a supplement for ruminants that are restricted to dry mature herbage deficient in protein. It is a relatively simple matter for stock-food manufacturers to incorporate urea in concentrate mixtures. In the field, however, the feeding of urea is difficult because in the absence of thorough mixing, foodstuffs can be made unpalatable and serious losses may occur through poisoning. Qualified successes have been achieved by the use of mixtures of urea and molasses. These can be sprayed on to hay or dry pasture. Under many conditions, however, hay is not fed in significant quantity nor is the pasture stand sufficiently dense to justify the use of sprays.

It is surprising, therefore, that little if any attention has been given to the supply of urea to stock through drinking water. Particularly is this so when urea is most likely to be of value under conditions where stock have to drink from reticulated water supplies. Tests at this Laboratory have shown that Merino sheep will drink normal amounts of water containing appreciable amounts of urea without suffering any apparent ill effect.

A daily intake of five grams of urea should be a useful supplement to a sheep on dry mature herbage, even though this may be lacking in readily available carbohydrate. This amount of urea would supply nitrogen equivalent to 13 grams of crude protein. At this Laboratory preliminary tests have shown that as much as 15 grams of urea can be given in the drinking water consumed daily by a Merino wether. This amount could be toxic if given in one dose with a stomach pump.

Pen Trials

The tests were carried out during hot dry weather with sheep in pens restricted to a ration of dry cereal chaff. Even so, water consumption fell when urea was added to the drinking water. In the final test each of two ewes were given a daily ration of one litre of water containing ten grams of urea. The sheep behaved normally and maintained body weight on this intake over three weeks.

A trial was then conducted with ten sheep under paddock conditions. Eight gallons of water containing 50 grams of urea was made available in a trough each morning. For 14 days the sheep consumed most of this water without ill effect.

Field Trials

Following these trials, field tests involving 7000 sheep were carried out by Mr. R. A. Shepherd of Kwolyin.

First Trial: Fifty-six lb of urea were added to each of four tanks holding 6,000 gallons of water. This is equivalent to 4.2 grams urea per gallon. The water was reticulated to drinking troughs through ball-cock taps.

No ill effects were seen in the sheep drinking water from three of the treated tanks but eight

dead sheep were found near the trough supplied by the fourth tank. This trough had been cleaned out immediately after the urea had been added to the tank. Presumably the urea crystals sank to the bottom and a highly concentrated solution ran into the trough when this was filled. There was a strong smell of ammonia in the trough when it was cleaned out. A certain amount of water was allowed to run off, the trough was again filled and no further losses occurred.

Second Trial: Four weeks later a further 56 lb of urea were added to each tank, the crystals being suspended in bags near the top of the water. Forty tanks were treated in this trial. Water was consumed normally at thirty-nine of the troughs without any suggestion of trouble. At the fortieth tank, however, seventeen sheep died following replenishment with a second lot of urea. This was one of two tanks supplying one paddock. The sheep drank mainly from one tank so that the second tank received a double-dose when the second lot of urea was added. This tank also supplied a second paddock into which sheep were placed after the second lot of urea was added. The losses occurred among these sheep.

These tests indicate that water may be used as a vehicle for the administration of the urea to sheep. However, it is apparent that losses can occur in the field if mistakes are made in the use of the urea. The tests with sheep in pens gave rise to the hope that water containing toxic levels of urea would be too unpalatable to be consumed in fatal doses. The field trials indicate that such is not the case. Either from habit, or the tendency to follow the leader, sheep may imbibe excessive urea through drinking water.

Future Work

Information is still required concerning the conditions under which it will be profitable to feed urea to sheep. Mr. Shepherd is pleased with the even quality of the wool on the sheep which had access to treated water and controlled experiments to determine the benefits seem justified. If water is to be used as the vehicle, tests will also be necessary to determine the stability of urea in water under field conditions and the need, if any, to control the growth of water borne organisms.

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Effect of Hexoestrol Implantation on Growth Rate and Carcass Quality of Weaner Lambs

During the last few years a good deal of publicity has been given to the use of hexoestrol for increasing the efficiency of fat lamb production. The variable results of experiments conducted overseas indicated that lambs do not respond uniformly to hexoestrol implantation. The need for investigations carried out under Australian conditions was obvious. Recently McHugh and Cannon (1958) reported an experiment carried out in North Eastern Victoria in which no advantages resulted from the implantation of suckling lambs with 15 mg of hexoestrol per head.

In cooperation with the Mornington Peninsular Fat Lamb Producers' Association we have recently concluded an experiment in which the effect of hexoestrol implantation on

the growth rates, carcass weights, and carcass qualities of weaner lambs was investigated. The experiment was carried out on the Moorooduc property of Mr. G. J. R. Coles.

Method

Two separate drafts of fat lamb weaners were used. The first draft consisted of seventy-two 5 month old Hampshire X Border Leicester/Merino weaners and the second draft of thirty-six 7 month old Hampshire X Border Leicester/Merino weaners and eighteen 7 month old interbred Border Leicester X Merino weaners. Both drafts were divided into halves of similar sex, liveweight, and breed distribution, and each lamb in one half of each draft was then implanted at the base of the ear with 15 mg of hexoestrol. Both groups in the first draft were slaughtered 34 days after implantation, and both groups in the second draft were slaughtered after 48 days. All of the lambs were grazed together on rape and turnips, and each lamb was weighed weekly. Before the initial and final weighing the lambs were yarded for sixteen hours.

When slaughtered the carcasses were graded for export, weighed to the nearest ounce in air and water, and their specific gravities were calculated. Observations were made concerning the ease of skinning and the degree of udder development.

Results

Table I summarises the results, and the figures given show clearly that the use of hexoestrol had a significant effect on the liveweight gains of the lambs in the second draft but not in the first. The carcass weights did not differ significantly in either draft. By substituting the determined specific gravities (S.G.) in the equation:

$$Y = 100 \left(\frac{5.680}{S.G.} - 5.138 \right)$$

Where Y is the percentage ether extract (chemical fat) of carcass (Barton and Kirton 1956) the percentage of chemical fat in the carcasses was calculated and again no significant differences were detected. The percentage fat in the treated carcasses averaged 41.5 and in the untreated 42.5.

At the meat works, treated and control groups were regarded as a single mob, and individuals passed at random, along the killing chain. As the skin was removed from each carcass the slaughterman, who knew nothing about the experiment, recorded whether the process was *easy* or *difficult*. Thirty-seven per cent. of the treated carcasses and 7.2 per cent. of the controls were recorded as difficult. All carcasses were graded into two classes according to udder development by an experienced grader, who also had no knowledge of the

TABLE 1.

Mean liveweight gain, mean carcass weight and mean specific gravity of carcass, of treated and control groups.

Draft	Group	Initial Liveweight (lb)	Mean Liveweight Gain (lb)	Difference ± S.E.	Mean Carcass Weight (lb)	Difference ± S.E.	Mean Specific Gravity
1	Treated	59.5	8.7	0.6 ± 1.09	34.1	0.5 ± 0.95	1.025
	Control	59.3	9.3		34.6		1.026
2	Treated	61.8	12.6	*3.0 ± 1.03	35.7	0.3 ± 1.27	1.020
	Control	62.4	9.6		35.4		1.016

*P $\leqslant$ 0.01.

experiment. Forty-eight per cent. of the treated carcasses and 11 per cent. of the controls were classed as having excessive udder development. In the treated group 7.2 per cent. of the udders had milk oozing from them; this was not observed in any of the untreated carcasses.

Discussion

The results of this experiment on weaner lambs agree broadly with those reported by McHugh and Cannon (1958) Averill (1955) and Lambourne (1958) on sucker lambs. Although the response to the implantation of hexoestrol in terms of liveweight was variable, in terms of carcass weight it was insignificant and the quality of the carcasses was depressed.

These results apparently disagree with those reported by Preston and Gee (1957). These workers claimed that "hexoestrol implantation of weaned lambs . . . caused a significant increase in liveweight gain and an apparent improvement in carcass quality", and on the basis of their work they concluded that "as long as consumer demand is for leaner meat there are distinct advantages to be gained from hexoestrol administration". However, it must be remembered that as far as their work on weaned lambs was concerned they had only six animals in the treated and control groups and the difference between the mean daily liveweight gains of each group was not, in fact, statistically significant. Indeed the conclusion arrived at by these authors becomes even harder to understand when it is realised that in an investigation carried out at the same research station, using six separate farm flocks totalling 524 weaned lambs, an increased liveweight gain due to hexoestrol implantation was obtained in only one flock (Gill, Thomson and Crichton 1956). Also although a significantly greater rate of liveweight gain due to hexoestrol was reported in a group of nine months old sheep housed indoors and fed a concentrate ration (Gill, Thomson and Crichton 1956) the carcasses of the treated sheep were of a lower grade than those of the controls.

In view of the agreement between results of experiments carried out by different workers with grazing sheep in Australia and New Zealand we feel that hexoestrol implantation should not yet be recommended to fat lamb producers.

Acknowledgments

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Mistletoe Control
A Field Trial

The control of mistletoe by trunk injection of parasitised trees reported by Greenham *et al.* (1951) appeared to offer advantages over the spray method of control advocated by Hartigan (1949).

Accordingly, a field trial was arranged on a co-operative basis between the Department of Main Roads and Forestry Commission of N.S.W. to test the efficiency of the process under normal practical conditions.

The location of this trial was northern N.S.W. along the main New England Highway between Tamworth and Armidale. One thousand trees (eucalypts) infested with mistletoe were treated and comprised gums, boxes, peppermints, stringy and ironbarks. The predominant mistletoe was *Amyema miquellii* Tiegh.

The process described by Greenham & Brown (1957) was followed in detail and in addition modifications of this process were employed in an attempt to simplify the application. The molifications were principally to incorporate 2,4-D amine salt into a paste of carboxy methyl cellulose and apply to incisions made at the base of the tree.

The trees were treated in batches to cover seasonal susceptibility, if any, and a point score was kept which related improvement in condition of tree to presence of living mistletoes.

TABLE 1.

Percentage improvement in tree and percentage mistletoe kills in five trials 1954-1955.

October, 1954 treatment

Time since treatment	*Method	% Improvement in tree	% Kills mistletoe
7 mths	1	80	53
	2	80	23
	3	63	15
	4	50	23
	5	62	16
	6	0	0
11 mths	1	83	63
	2	95	35
	3	63	15
	4	73	45
	5	76	32
	6	7	0
19 mths	1	85	63
	2	95	33
	3	55	20
	4	70	43
	5	78	38
	6	7	0

*Method 2 is the C.S.I.R.O. treatment after Greenham & Brown.
Method 6 is control.

May, 1955 treatment.

Time since treatment	*Method	% Improvement in tree	% Kills mistletoe
1 mth	1	0	0
	2	17	8
	3	8	7
4 mths	1	4	1
	2	35	27
	3	18	8
12 mths	1	9	4
	2	56	56
	3	27	15

*Method 1 is C.S.I.R.O. treatment.

November, 1954 treatment.

Time since treatment	*Method	% Improvement in tree	% Kills mistletoe
6 mths	1	26	0
	2	42	8
	3	58	30
	4	13	0
10 mths	1	33	1
	2	47	16
	3	49	34
	4	13	0
18 mths	1	40	3
	2	46	28
	3	57	37
	4	7	0

*Method 1 is C.S.I.R.O. treatment.
Method 4 is control.

June, 1955 treatment.
(1)

Time since treatment	*Method	% Improvement in tree	% Kills mistletoe
3 mths	1	0	0
	2	39	34
	3	4	4
11 mths	1	10	4
	2	63	55
	3	35	15

(2)

Time since treatment	*Method	% Improvement in tree	% Kills mistletoe
3 mths	1	16	5
	2	10	10
	3	7	3
11 mths	1	38	14
	2	26	20
	3	28	15

*Method 1 is C.S.I.R.O. treatment.

Results of these treatments are set out in Table 1.

It was felt from these results that the injection method did not warrant adoption as a routine practice on a commercial scale.

At the same time results were felt to be sufficiently promising to justify further experimental work with the accent directed on the agricultural aspects of mistletoe damage rather than the sylvicultural.

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Greenham, C. G. and Brown, A. G. (1957)—The Control of Mistletoe by Trunk Injection, *J. Aust. Inst. Agric. Sci.* **23:** 308-17.

D. HARTIGAN,

Division of Wood Technology,
Forestry Commission of N.S.W.,
Sydney.

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WANTED

The Business Manager of the Journal, J. A. Roberts, would be pleased to receive any unwanted copies of the following issues of the Journal:

Vol. 7, No. 3	(Sept. 1941)
Vol. 10, Nos. 1, 3 and 4	(Mar., Sept., Dec. 1944)
Vol. 15, No. 1	(Mar. 1949)
Vol. 16, No. 4	(Dec. 1950)
Vol. 17, No. 1	(Mar. 1951)
Vol. 22, Nos. 1 and 3	(Mar. and Sept. 1956)

Theses on which higher Degrees were Awarded in the Faculties of Agriculture of Australian Universities — 1957

University of Adelaide

Ph.D.	R. R. Rawat	The biology and morphology of *Agrostis infusa* Boisd.
Ph.D.	R. J. Millington	Seedling growth in relation to oxygen concentration and investigation on soil structure and aeration.
Ph.D.	K. B. Rajbhandry	A study of water use and dry matter production of lucerne under irrigation and natural rainfall.
M.Ag.Sc.	K. T. Joseph	Availability and reversion of phosphorous in soils.

University of Melbourne

Ph.D.	J. R. Phillips	Skew forces and couples; the trailed disc plough, the oblique rolling wheel.
M.Ag.Sc.	N. J. Barrow	An investigation into the renovation of phalaris pastures in the Northern Tablelands district of N.S.W.
M.Ag.Sc.	F. Cope	Salting in Victorian catchments.
M.Ag.Sc.	Mrs. B. M. Edmonds	An examination of the problems of estimating the thyroid hormone level in the blood of domestic animals, and the effects of varying that level on the marketable products of such animals.
M.Ag.Sc.	R. H. Taylor	An investigation of the viruses which cause woodiness of passion fruit.
M.Ag.Sc.	N. V. Villarta	The production of diacetyl by *Streptococcus diacetilactis* in mixed starter cultures.

University of Queensland

D.Agr.Sc.	P. J. Skerman	The Channel Country of South West Queensland with special reference to Cooper's Creek.
D.Agr.Sc.	N. T. M. Yeates	Photo periodic control of coat changes in cattle with particular reference to the tropical adaptation of European breeds.
M.Agr.Sc.	C. S. Andrew	Nutrient requirements of pasture species on the coastal lowlands of Southern Queensland.
M.Agr.Sc.	N. Vera Cruz	Artificial insemination of pigs.

University of Sydney

D.Sc.Agr.	S. Smith-White	Cytological studies on the Australian Flora.
Ph.D.	J. S. Bunt	Microscopic and submacroscopic organisms in the soils of the Macquarie Island ecosystem.

Ph.D.	A. D. Rovira	Factors influencing soil metabolism and the relationship between plant roots and soil micro-organisms.
M.Sc.Agr.	M. W. McDonald	The effects of supplementary D1 Methionine in certain chicken diets.
M.Sc.Agr.	R. G. Marquez	Studies in the root nodule bacteria.
M.Sc.Agr.	J. W. McGarity	Soils of the Richmond-Tweed region—a study of their distribution and genesis.
M.Sc.Agr.	K. Scott	Some biochemical aspects of host-pathogen relations in powdery mildew of barley.
M.Sc.Agr.	W. R. Stern	Factors influencing cropping in a tropical environment.
M.Sc.Agr.	Barbara J. Williams (nee Carne)	Host-parasite relations in rust of subterranean clover.

University of Western Australia

M.Sc. (Agric.)	J. A. Carpenter	The induction of mutations in subterranean clover by X-irradiation.
M.Sc. (Agric.)	E. H. Lawson	The influence of seed size on the growth of two strains of subterranean clover.
M.Sc. (Agric.)	R. G. Mauldon	Linear programming in its application to farm management analysis.
M.Sc. (Agric.)	J. H. Silsbury	Studies in the genus *Kennedya* Vent.

Thesis Summary

Catchment Salting in Victoria

The localised accumulation of excessive amounts of soluble salts in soils under natural rainfall conditions is becoming increasingly troublesome in Western and Southern Australia. An investigation of this problem in Victorian catchments is reported in this thesis. The incidence of salting was surveyed and the area affected estimated at more than 10,000 acres. This acreage is extending, but the main economic importance of salting is in the erosion which it induces.

The ecosystems under which accumulation of salt in soils can take place contain most of these factors:

1. The presence of chlorides of oceanic origin in soils, which can best be accounted for by the cyclic salt theory.
2. Low P/E ratios, such as are found in many parts of Victoria.
3. Vegetation with high water usage—the catchments in which salting now occurs were formerly well forested.
4. Soils having an impermeable horizon at no great depth—salting in Victoria is largely confined to such soils.

In undisturbed catchments with such an ecosystem the hydrological equation is approximately:—

Precipitation = Evaporation + Transpiration.

Following excessive clearing and overgrazing, transpiration is greatly reduced, and movement of water on and below the ground can take place. Erosion by surface run-off is obvious, but subsurface flow can transport salts laterally, until an impediment halts the flow and allows salt concentration by evaporation. The types of salting which are produced are described.

Drainage, the use of trees and shrubs, and pasture improvement are dealt with in a general way. Detailed results are given of experiments with fertilisers, soil conditioners, and some sixty plants for saltland reclamation. Control of salting is possible, especially if action be taken during the early stages, but preventative measures in areas of incipient salting are best. Nitrogen fertilisation is especially important in revegetating saltland.

This work was carried out as a research project of the Soil Conservation Authority of Victoria and a large part of it will be published shortly by the Authority as a research bulletin entitled "Catchment Salting in Victoria".

F. R. COPE

Awarded the degree of M.Agr.Sc. by the University of Melbourne, 1957.

COMMONWEALTH AGRICULTURAL BUREAX

Applications are invited for the post of—

DIRECTOR, COMMONWEALTH BUREAU OF HORTICULTURE AND PLANTATION CROPS, EAST MALLING RESEARCH STATION, NR. MAIDSTONE, KENT, ENGLAND.

The work of the Bureau is to collect, collate and make available to research workers information on the cultivation of horticultural and plantation crops. Salary scale £2,000-£2,300, with provision for superannuation.

Applications should be submitted by 31st January, 1959, to the Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks., England, from whom full particulars, including regulations about provision of passages to overseas candidates on first appointment, can be obtained.

Talks

Science in Modern Affairs

Mr. L. J. F. Brimble, Joint Editor of "Nature", in an address to the South Australian Branch.

The scientific journal "Nature" was founded with the objectives of providing a forum for scientists and interpreting science to the non scientists. The founders included not only leading scientists such as Darwin and Huxley but also non scientists such as Charles Kingsley and Dean Harrow. Today, however, it is impossible to carry out both these functions properly, as science is becoming more intensive. This is reflected in the large number of scientific journals in the world—50,000 in 1950.

Mr. Brimble made the following comments on articles submitted to "Nature":—

1. Far too much work is rushed into print in an effort to claim priority. There is not as much teamwork among scientists as there ought to be.
2. Far too many papers are written with the mistaken idea that their value is proportional to their length.
3. Contributors from foreign countries often write confusing English.
4. The use of jargon and abbreviations is to be deplored. Frequently, abbreviations are used which are already common in another science.

Up until 1936/37, scientists from all parts of the world subscribed to "Nature" but from then on politics began to interfere, particularly on issues of freedom for science. There were no contributors from Germany for many years and since 1947 none from Russia and Iron Curtain countries.

Science has become a very important aspect of modern life but the danger lies in its application. It is becoming increasingly difficult to keep scientific research on a "seeking the truth" basis. Political leaders are "playing around" with scientific achievements and this is giving bad publicity to scientists.

In Australia both the appreciation and interpretation of science is deplorable yet it is most important that the public should know more about science. The scientific press must learn to interpret science for the laymen. This is being done in the U.S.A. and to a lesser extent in the backward countries. Often the local papers give a better cover than the national ones.

Mr. Brimble strongly suggested that some form of scientific appreciation be incorporated in the curriculum of all schools. It was not necessary to be able to do science to appreciate what it can do.

Progress in Bloat Research in New Zealand

Mr. C. S. W. Reid, D.S.I.R., New Zealand, in an address to the Melbourne University Agricultural Society, August 7.

Mr. Reid stated that an average of 10,000 cows is killed by bloat each year in New Zealand. However, all cows affected by bloat suffer a considerable drop in production and the loss of yield from those that don't die is greater than the loss owing to deaths.

Causes

For a long time two theories regarding the cause of bloat were held by research workers:

1. Prevention of belching. Gas produced by the rumen micro-flora is normally belched out by the cow. Where a large quantity of "free" gas was present in bloated cows it was thought that the muscles responsible for belching had somehow become paralysed. This was called "free" bloat.

2. Formation of excessive foam. Here the gas produced by bacterial fermentation is for some reason caught up in a very stable foam in the rumen. This was called "frothy" bloat.

Research workers now consider that all bloat is probably "frothy" bloat. Some free gas may be present but a number of post-mortems have shown that excessive foaming is always present. Some foaming occurs whenever cows graze on legumes but for some reason the foaming in bloated animals is excessive.

What causes foaming? A number of factors could be involved. However, a foaming agent must be present—this was thought to be the saponins in legumes but it now seems that proteins or protein break-down products in feed are likely to be the culprits. Also, saliva may add foam-producing proteins to the rumen. Some rumen bacteria may add foam-producing slimes but this seems to be a minor factor under grazing conditions.

Besides foaming agents, gas-producing bacteria must be present in the rumen. Stable foams are probably only formed if there is an adequate supply of salt in the rumen and if the pH of the contents is about 6. The salt level is usually adequate. Where a foaming agent is only present in small quantities the cow can get rid of all excess gas by belching.

Treatment

As bloat is sporadic in its occurrence it is necessary to have carefully controlled experiments in research work. In New Zealand the use of identical twins took care of this problem. On many different treatments tried, anti-foaming agents were the only ones to effectively break down foam.

The most reliable of these were vegetable oils, animal fat, paraffin oils and whale oil. Bloated cows take at least 30 minutes to recover after administration of most anti-foaming agents. Variations in recovery times when vegetable oils were used may have been due to the rates at which oils spread in the rumen.

The next step was to find an anti-foaming agent with no ill-effect on the health of stock or on the quantity or quality of milk and butterfat. Paraffin oils such as kerosene put cows off their food, although a dose of 150 ml. per day of medicinal paraffin was harmless for a period of up to 6 weeks. Paraffin interferes with the uptake of carotene and vitamin E in the diet, and the reserves of these in the treated animal could become exhausted after 6 weeks. This does not apply under grazing conditions but it could be a consideration with "feed lot" bloat in U.S.A.

Anti-foaming agents which caused least taint and other ill-effects in butter and milk were peanut oil, tallow and liquid paraffin (for limited periods).

Prevention

One of the oldest ideas was to dilute bloaty feeds with harmless feeds such as ryegrass. This was not easy in New Zealand where it was found that cows could bloat on pastures with as little as 30 per cent clover. However, mature grassy pastures provide the safest grazing. H.I. ryegrass is a good grass species in the sward as it is fairly palatable, even when rather mature.

Another method was to restrict clover intake by controlled grazing. However, it was found that some cows would bloat on as little as 12 lb. of potent clover. Also, production can suffer through restriction of intake of potent pasture.

One of the newest and most effective methods is the use of anti-foaming agents. These are simple to use over short periods because a cow can receive an anti-foaming agent in the bail and be protected from bloat for up to 4 hours. Over longer periods the anti-foaming agent is likely to be lost from the rumen. Heavier doses to combat this are too costly and could be harmful. "Carriers" were designed which it was hoped could release anti-foaming agents slowly, but these were not successful. Small and frequent amounts of hay or meal "treated" with an anti-foaming agent would be effective but cows can not be relied on to eat them. Drinking water treated with anti-foaming agent is not to be depended on as cows vary in their drinking habits.

Up to date, direct spraying of bloaty pastures with emulsified peanut oil, emulsified tallow or emulsified paraffin has given the best results.

Penicillin. This was first tried in America. It reduces the rate of gas production in the rumen and does not harm cows. First New Zealand trials with penicillin were successful. Later ones showed that a "resistance" could be built up in cows and protection lost. This resistance may last from season to season, but so far there is insufficient knowledge on the subject.

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SERVING INDUSTRY . . .
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News Items

Australian Appointed Chief of Agricultural Division of World Bank

Mr. P. A. Reid

A well-known Australian agriculturist and Institute Member, Mr. P. A. Reid, has been appointed Chief of the Agricultural Division of the International Bank for Reconstruction and Development (World Bank). Before joining the Bank in 1955, Mr. Reid was Assistant Director of the Commonwealth Bureau of Agricultural Economics, Canberra.

Mr. Reid received his early training in agriculture at Melbourne University. This was followed by 15 years of practical farming at Glenmore station, Scone, New South Wales. Mr. Reid then took up professional work as agriculturist to the Bank of New South Wales. After war service he joined the Rural Division of the Department of Postwar Reconstruction, which later became the Bureau of Agricultural Economics. While with the Bureau Mr. Reid was in charge of the wool research program and aspects of the Bureau's work relating to land use and development.

Institute Members Contribute to Regional Study

Research and extension officers of a number of organisations are contributing to a co-operative study sponsored by C.S.I.R.O. and the Department of Agriculture, N.S.W. The aim of this project is to study the current and potential production on the Southern Tablelands of N.S.W. as a basis for deciding what further research, extension activity and economic resources may be needed to exploit that potential.

As a preliminary step special attention is being given to a study of the Yass River Valley. This valley is typical of many in the region. *Mr. J. Basinski* has prepared a report on the water resources of the valley and *Mr. R. Slatyer* and *Mr. D. van Dijk* are describing the climate and the soils as a basis for further planning. *Mr. A. Lloyd* has conducted a farm survey to show the current pattern of farm practice. Results will appear as a series of articles in the Review of Marketing and Agricultural Economics.

The study is being guided by a joint committee of which *Mr. R. Shelley,* Regional Supervisor, Department of Agriculture, is Chairman and *Mr. A. F. Gurnett-Smith,* Canberra Liaison Officer C.S.I.R.O., is Secretary.

New Journal

A new scientific Journal entitled *Developmental Biology* is to be published in the U.S.A. in January 1959.

The purpose of the new journal is to assemble in one medium papers dealing with development in the broadest sense. It will contain articles bearing on problems of embryonic and post-embryonic development, growth, regeneration, and tissue repair, of both plants and animals. Thus, this new periodical will serve as meeting ground for botanical and zoological approaches, drawing on concepts and techniques of a wide range of disciplines, e.g., biochemistry, biophysics, cytology, embryology, experimental morphology, genetics, immunology, microbiology, and pathology. Whatever the organism or the method of study used, the principal criterion of acceptibility will be the degree of focus on developmental problems.

Developmental Biology will be an international journal, publishing papers in English, French, or

German. All manuscripts in the English language, and all enquiries regarding editorial policy or the preparation of papers, should be sent to: *Developmental Biology,* Department of Biology, Brown University, Province 12, Rhode Island, U.S.A.

Fifty reprints of each article will be available free of charge. Volume 1, at $14.00, will consist of six bimonthly issues. Subscription orders should be sent to the publishers, Academic Press Inc., 111 Fifth Avenue, New York 3, New York.

Managing Editor is Dr. M. V. Edds Jr., Brown University, Rhode Island, U.S.A.

New Laboratories for Division of Soils, C.S.I.R.O.

A new laboratory has recently been built for the C.S.I.R.O. Division of Soils on a picturesque foothills site, lined with gum trees, at the Adelaide suburb of Glen Osmond. The site, formerly part of the grounds of the Waite Agricultural Research Institute, was generously made available to C.S.I.R.O. by the University of Adelaide on a long term lease. The new laboratory is just over the road from the laboratories of the Waite Institute and is also adjacent to the newly established Australian Wine Research Institute.

The development of the site and the move of the Administrative staff and the sections of Pedology and Soil Chemistry brings to fruition the long term plans to establish the Headquarters of the Division in its own buildings. Since its foundation in 1929 the Division has been housed in the laboratories of the Waite Institute. Although the sections of Physics and Microbiology will remain there for a time and the section of Clay Mineralogy in the Mawson building of the University, plans for additional accommodation will bring all sections of the Division together in the near future.

The new building is a single storey cream brick structure with a bold but pleasing architectural treatment of the entrance in random uncoursed sandstone. The long axis of the building faces WNW, overlooking the Adelaide plains. With an ancillary building at the back it provides approximately 12000 sq. ft. of floor space.

The South Wing includes a Conference Room, a large well lighted drawing office and Map Room and suitable office accommodation for the pedologists.

The Chief's office and all the administration officers are also in this wing.

The North Wing has been designed primarily for Chemistry although two rooms are being temporarily occupied for library purposes. The laboratory is arranged to facilitate the handling of large numbers of soil samples taken in association with soil surveys and pedological studies. Special equipment includes plummet balances, an automatic sand washing machine, flame photometers, absorptiometer, and spectrophotometer besides the usual equipment of ovens, balances, hot plates, water baths, etc. Two small cubicles make provision for glass blowing and the sub-sampling and weighing of dusty samples respectively.

The instrument room and one research laboratory are each 23 feet long by 10 feet wide, a size and shape that is proving very effective and convenient. Several research laboratories along the western face of the building have been designed for two research workers each. Each room is well lighted from the large windows of the western face and is well equipped with an open fronted fume hood, wall and island benches, and writing desks. The cupboards and bench tops have been finished in natural colour, the bench tops being protected with an epoxy type finish.

Two physico-chemical laboratories, a small one for routine purposes and a larger one for research, are equipped with thermostatic controls to maintain a temperature of 20°C or 25°C as required. Another room is being fitted as a radio-active tracer laboratory.

Services to the laboratories include high and low pressure water (the latter for water baths and condensers) compressed air, gas and power. Heating of the building is by means of hot water radiators from an oil fired boiler. An electric still in the under-roof area supplies distilled water which is reticulated through a polythene storage and piping system to three convenient points in the laboratory wing. Special conductivity water is obtained from a small de-ionization unit in one of the research laboratories. Polythene piping has been used exclusively for all laboratory wastes and this should provide a non corrodible drainage system. Small oval or circular polythene drip cups are conveniently placed flush with the bench surface to receive effluent from condensors or filter pumps. All fume hoods are the standard pattern C.S.I.R.O. open fronted type.

Further development of the site is in progress and a glasshouse, potting shed and instrument workshop are under construction. Plans are also in hand for the second laboratory building to house Physics, Spectrography, Microbiology, Clay Mineralogy and Microscopy and so bring together once again the whole of the headquarters sections of the Division.

The first glasshouse is an Alumabrite prefabricated structure 72 feet x 30 feet and consists of a glass roof and duralium mesh sides primarily designed for pot experiments in soil chemistry and soil fertility. The potting shed will contain services necessary for the efficient functioning of the glass house work.

The Australian Agricultural Economics Society 1959 Conference — Melbourne

This Society will hold its Third Annual Conference in Melbourne, at the School of Agriculture, University of Melbourne, from Tuesday, February 24, to Thursday, February 26, 1959.

The Conference Programme will, it is proposed, take the following form:

Tuesday, February 24:

8 p.m. *J. G. Crawford*: Presidential Address.

Wednesday, February 25:

9 a.m. *Sir Samuel Wadham*: "U.K. Agricultural Policy and the Australian Farm Programme."

11.30 a.m. *G. O. Gutman*: A paper on Australia's cost and income levels compared with those of competition countries.

2 p.m. *Drs. D. B. Williams* and *H. J. Falding*: A symposium on Extension.

Thursday, February 26:

9 a.m. *Dr. W. Candler*: "A New Look at Budgeting from the standpoint of Linear Programming."

11.30 a.m. *Annual General Meeting* of the Society.

2 p.m. *Dr. H. C. Coombs*: A paper on some aspects of the rural credit situation in Australia.

A Buffet Tea and Sherry Party will precede the first session of the Conference on Tuesday, 24th February, 1959.

Arrangements have been made for accommodation in one of the University Colleges, where full board will be provided at £2 per head per day. The Hon. Secretary of the Society is C. P. Dowsett, c/o Rural Bank of N.S.W., Martin Place, Sydney.

Farm Management Specialist Gains High Award

Dr. W. V. Candler, Lecturer in Farm Management in the Faculty of Agricultural Economics at the University of New England, has recently been awarded a prize of 250 dollars given by the American Farm Economic Association for the best Doctor of Philosophy thesis presented at any American University in the field of Agricultural Economics in 1957.

Dr. Candler's prize winning thesis dealt with Linear Programming with Variable Yields and incorporated research work he has carried out at Iowa State College, U.S.A., during the 2½ years he spent there working with Professor Earl Heady. Linear Programming is an advanced form of budgeting by which it is possible to consider at the same time the many different ways that a farmer or grazier could possibly earn his income from a given property.

As well as holding a Doctor of Philosophy degree from the University of Iowa, Dr. Candler holds an Honours degree in Agricultural Science from Massey Agricultural College, New Zealand.

He is joint author with Professor Heady of a book entitled "Linear Programming Methods".

Refresher Course

In early September a refresher course, "Agricultural Science Today", was held at Sydney University under the sponsorship of the Extension Board in conjunction with the Faculty of Agriculture.

Sixty-three graduates enrolled for the course, which was well appreciated particularly by the graduates of longer standing.

Twenty lectures, each of one to one and a half hours, comprised the course, which tended to be biased towards the plant fields; only 3 topics pertaining to animals were included.

Student Society

A new organisation to promote the interest of agricultural students throughout Australia has been formed under the name Australian Association of Agricultural Faculties.

The Association is a federated body of University Agricultural Students' Societies. Its objects include the encouragement of an interchange of ideas in all fields of education and practice of agricultural science and the fostering of interstate student exchange and vacation work, as well as international exchange of individual students. The Association will also recommend to the National Union of Australian University Students the policy it should adopt on any issue affecting agricultural students.

The Association was launched at a conference in Sydney at which Universities in every mainland State were represented. At this it was pointed out that graduates in agricultural science had their own Associations, and there was need for an undergraduate body in which members could discuss mutual problems.

One of the early decisions was to apply immediately for affiliation with the Australian Institute of Agricultural Science.

The 1959 conference will be held in Melbourne at a date yet to be fixed. Melbourne will be the Executive University in that year.

The present office bearers are:

President: *Frank Hampshire* (National Director); Hon. Secretary: *Bob McIntosh;* Hon. Treasurer: *Grant Stone.*

Victorian Branch Sub-Committee on Undergraduate Affairs

A. J. VASEY

The Sub-Committee on under-graduate affairs was appointed in 1953 to provide some form of guidance to new graduates on their first appointment.

It consists of the Professor of Agriculture and four corporate members of the Branch.

No member is regarded as representative of his employment group; all are graduates of the Melbourne School who have had experience in various forms of professional activity, and in the recruitment of graduate staff.

The Branch Committee does not regard the members appointed to the Sub-Committee as vocational guidance specialists and the members themselves would be the last people to claim such qualifications. Characteristics which they do have in common, however, are an interest in the problems of young people and a willingness to listen and to help as best they can.

Terms of Reference—

The following are the terms of reference for the Sub-Committee's activities:

> "To keep constantly under review the welfare of undergraduate members of the Institute and to recommend to the Victorian Branch Committee ways in which their interest can be stimulated and maintained by attention to their needs during their undergraduate and first post graduate years."

These have proved adequate for activities to date but it may be necessary to seek an extension of reference to cover a longer period.

Method of Working

The Convenor or his representative addresses a lunch hour meeting of all agricultural students during July each year. He explains something of the Institute's work and invites all students to meet the Sub-Committee members at a later date.

The number of those accepting invitations for interview is given in the following table:—

Year	No. in 4th Year	Number Interviewed	Percentage
1953	25	18	72
1954	16	12	75
1955	16	15	94
1956	20	17	85
1957	37	27	73
1958	35	24	69

The August Interviews—

The date selected for the first interview has not been chosen at random. The Professor has noted year after year a progressive change in maturity of outlook during the Fourth Year. For this reason the date of interview should be as late as possible. However, few students like to admit that they can give up even one evening in Third Term when preparation for final examinations is uppermost in their minds. Hence the present arrangement for last week in second term.

The time table for the interviews is arranged on a 20-minute basis starting at 5.20 each evening.

There is no set form for discussion during the interviews. Where the student has indicated a preferred field of work on graduation the discussion is directed to determining his (or her) capacity for this activity and as to whether there has been sufficient background experience to make an intelligent choice. Where, as not infrequently happens, no choice is indicated, evidence is led as to the student's basic preferences by such questions as "Plants or Animals? Investigation or Extension? Economics?" Each interview is concluded by a short statement as to suggestions for further enquiry by the student, and/or as to the enquiries which the Sub-Committee proposes to make in the particular case, prior to the next interview in December.

Most of the Sub-Committee's contribution is made verbally in these discussions rather than in its

A. J. Vasey has been convenor of the Victorian Branch sub-committee on Undergraduate affairs since its inception.

written documents. However, each member of the Sub-Committee records his opinion of each student independently on his copy of the registration form. At the conclusion of the August series, these forms are returned to the Convenor, who prepares a paper giving all opinions recorded for attachment to each registration form, and returns to each member his file.

The December interviews—

The December interview follows a period of contact with prospective employers and further contact between many of the students and individual committee members. The interview itself is short (10 minutes or so) and is mainly for confirmation of previous discussions and correspondence.

Reports—

Each year the Sub-Committee prepares two documents, one the formal report to Branch Committee and the other giving its final comments on each student interviewed. In the report to the Branch the Sub-Committee reports on its activities during the year. The report giving comments on students interviewed is a confidential document to members of the Sub-Committee and to the Secretary of the University Appointments Board to whom it is transmitted by the Professor of Agriculture.

With What Result?—

It is not easy to assess the results of this form of Institute activity in terms of the number of graduates happily launched on professional careers. The members of the Sub-Committee prefer to regard the effect of their efforts as indirect. It is abundantly clear that some students benefit from talking over their plans and ideas with a group of people with experience in the general field of agricultural science; the real preferences of others have become clarified as a result of similar discussion. They therefore approach their first interviews with prospective employers in a more confident manner in the knowledge that there is a need for the kind of work they want to do. By these discussions also, others have been informed of the kind of activity and responsibility which will be expected of them in particular appointments in their early post graduate years; their settling down period is therefore shorter and less uncomfortable for both employer and employee. Briefly, the Sub-Committee endeavours to find the job for the man (or woman) and the man (or woman) for the job.

All these considerations tend to affect favourably the reaction of the community to the profession as a whole and to have a "snow-ball" effect which shows in increased opportunities for professional employment.

The Sub-Committee does not claim to have directly located additional positions for agricultural graduates. It is however probable that, through members' fairly wide contacts with Government departments and with industry, information is obtained more quickly in regard to positions which can be adequately filled by agricultural graduates, than would normally reach the Professor, or the University Appointments Board.

It is also true that the Sub-Committee's activities have become known to employing authorities and to private industry and that letters are sent direct to the Convenor asking the general question—"Is there likely to be a man for the following appointment this year?"

On the narrower issue of the effect of this and other services on Institute membership it is understood that every Melbourne graduate of recent years has become a member of the Institute.

Finally, for the members of the Sub-Committee this counselling has been a most rewarding experience. Although details of individual cases are condential, there have been a number of instances in which the help and advice given have had a most significant effect on the early careers of the graduates concerned.

Getting Rough Jobs Done is the Whole Function of the

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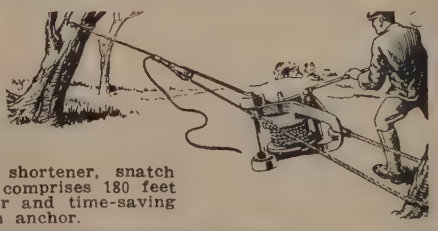

In the "Monkey" Grubber way clearing work is done expeditiously and without great outlay, leaving land ready for mechanical tilling. The machine delivers 260 times the power applied to the handle. It is portable and fitted with an automatic lowering gear, second speed, rope shortener, snatch block, etc. Cable equipment is generous and comprises 180 feet in four lengths each fitted with special labour and time-saving couplings. Takes an acre and a half from an anchor.

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First Fellows of the Australian Institute of Agricultural Science

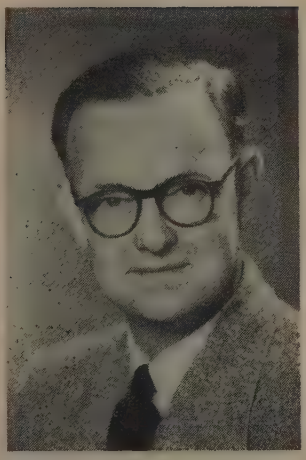
The class of Fellows of the Australian Institute of Agricultural Science was created to honour members who have made an outstanding contribution to the profession, or to agriculture in general.

The names of the first nine Fellows were announced on September 4, 1958.

The late Mr. A. F. Bell; then Under Secretary, Department of Agriculture & Stock, Queensland, was elected a Fellow before his death.

→

Dr. A. R. Callaghan, Director, Department of Agriculture, South Australia.



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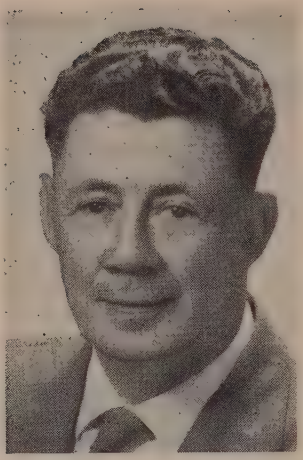
Dr. A. E. Cornish, Chief, Division of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organization.

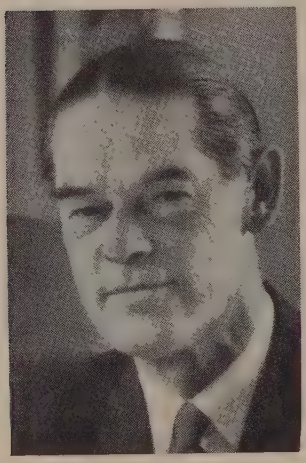
Mr. J. G. Crawford, Secretary, Department of Trade.

→

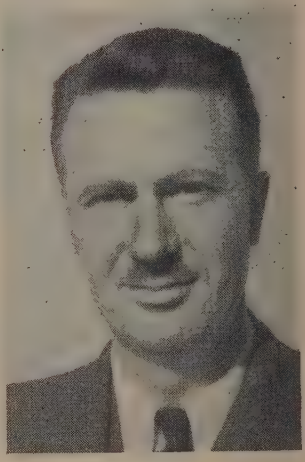


Dr. J. G. Davies, Associate Chief, Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, and Officer-in-Charge, Cunningham Laboratories, Brisbane.

Professor J. A. Prescott, Emeritus Professor of Agricultural Chemistry, University of Adelaide, and formerly Director, Waite Agricultural Research Institute.



Sir Ian Clunies Ross, Chairman, Commonwealth Scientific and Industrial Research Organization.



Professor E. J. Underwood, Professor of Agriculture and Director, Institute of Agriculture, University of Western Australia.

Professor Sir Samuel Wadham, Emeritus Professor of Agriculture, University of Melbourne.

Personal Notes

Australian Capital Territory

Mr. A. F. Gurnett-Smith, formerly of the Agricultural Research Liaison Section, Canberra, has transferred to the Division of Land Research and Regional Survey of C.S.I.R.O.

Mr. D. V. Walters of the Agricultural Research Liaison Section of C.S.I.R.O., Melbourne, is moving to Canberra to be the senior representative of this Section at the laboratories at Black Mountain.

Dr. O. H. Frankel has returned from his overseas trip in which he visited research institutions on the continent, in the United Kingdom, United States and New Zealand. Another overseas traveller who has now returned is *Dr. F. H. Morley* whose itinerary apart from New Zealand was similar to Dr. Frankel's. *Dr. D. L. Hayman* has returned from his three months lecturing at the University of Adelaide.

The Division of Plant Industry was pleased to receive a visit from *Dr. J. G. Davies,* the Associate Chief of the Division, who had discussions with some of the officers here and saw what developments had been taking place at Ginninderra Experiment Station which is the new experiment station for all the C.S.I.R.O. Divisions stationed in Canberra.

Other visitors to the Division have been *Mr. Norman Shaw* from the Brisbane laboratories and *Mr. Les Edye,* both of whom discussed agronomic work with officers of the Division.

Mr. W. P. Dunk of the State Rivers and Water Supply Commission, Victoria, visited the Division during August to discuss irrigation problems.

Mr. C. S. Christian, Chief of Division of Land Research, C.S.I.R.O., left at the end of October for a six-weeks' visit to the Rajasthan Desert, India. While there, Mr. Christian will advise the Indian Government on the organization of a Central Desert Research Institute which is to be established in Jodhpur.

Dr. R. W. Galloway, who recently arrived from England, has taken up a position of geomorphologist with the mainland survey unit of the Division of Land Research. Dr. Galloway has just received a Ph.D. Degree from the University of Edinburgh.

New South Wales

Mr. A. J. McIntyre recently returned from the International Conference on Agricultural Economics held at Mysore, India. Mr. McIntyre was away from Sydney for 6 weeks and visited Ceylon and Pakistan besides India.

Dr. M. C. Franklin was guest speaker at a meeting of the Queensland branch of the Institute, at which the Shell Oil Co. were hosts. Dr. Franklin's subject was "Control of Droughts in Queensland". He later visited parts of Western Queensland with *Dr. P. J. Skerman.*

Mr. Malcolm McDonald (of the Seven Hills Poultry Station) recently left Sydney to attend the International Poultry Congress in Mexico. He will be away 3 months.

Victoria

Mr. R. H. Macdonald of Potash Australasia Ltd. has returned from a five months trip to Europe and U.S.A.

Mr. A. L. Tisdall attended the recent A.N.Z.A.A.S. conference in Adelaide and contributed a paper to the symposium on "Post-War Land Development" (see Reviews).

Following his appointment, earlier in the year, as a Commissioner with the Victorian State Rivers and Water Supply Commission, Mr. Tisdall has accepted much of the responsibility of ensuring the effective

Mr. A. L. Tisdall

application of agricultural principles throughout the irrigation areas of Victoria.

He is well qualified to do this for, after graduating in 1932, Mr. Tisdall's experience was gained at the C.S.I.R.O. Research Station at Merbein, the Waite Institute in Adelaide and the Regional Pastoral Laboratory at Deniliquin.

In 1951 Mr. Tisdall joined the Water Commission as Chief Irrigation Officer and in this position and now as a Commissioner, his contributions to research and administration have proved of very great value to irrigation in the State.

Apart from official duties, Mr. Tisdall has also taken a keen interest in the activities of the Institute. In this capacity he has worked on the committee of the Victorian Branch for many years and was President during 1955.

The Institute takes this opportunity of congratulating Mr. Tisdall on his appointment to the Commission and wishes him continued success in his career.

Queensland

Dr. W. A. T. Summerville, Federal President of the Institute during 1957, has been appointed Under-Secretary of the Queensland Department of Agriculture and Stock.

Mr. Ross Downes has been granted a research assistantship at Cornell University where he will undertake a Ph.D. course in the Department of Plant Breeding. He expects to be allotted a project involving a study of the female gametophyte of *Bromus inermis* and hopes to make a special study of methods and techniques which will help him in his future grass breeding work in Australia.

Mr. Alex McDonald has relinquished his position in the Soil Technology Section of the Department of Agriculture and Stock, to take up farming at Tannymorel.

Mr. N. F. Fox, agrostologist with the Department of Agriculture and Stock, has transferred from Gayndah to Bundaberg.

During the University August vacation, a three weeks' tour of Northern Queensland was organized by *Dr. P. J. Skerman* for the fourth year agriculture students at Queensland University. The areas visited included the coastal regions as far north as Cairns, Green Island, the Atherton Tableland, Winton, the Central Highlands and the Callide Valley.

South Australia

Dr. J. Melville, Director of the Waite Institute, has been appointed a part time member of the C.S.I.R.O. Executive Committee.

Dr. R. J. Swaby returned from an overseas visit during which he visited 16 countries including U.S.S.R., India and Pakistan. While in the U.S.S.R., he visited 12 Scientific Institutes and 2 Collective Farms.

Mr. D. H. Penny, on a post graduate assistantship from Cornell University, is to establish a Rural Economics and Farm Management School in Sumatra under the auspices of a subsidiary of the Rockefeller Foundation. His initial appointment is for 2 years.

Mr. A. F. Tideman has been appointed Weeds Adviser in the S.A. Department of Agriculture. He was formerly a developmental officer in Shell Chemicals Ltd.

Dr. E. A. Cornish attended the Biometric Conference at Ottawa in August and will visit the U.K. and U.S.A. before returning in December.

Mr. D. W. Dewey of Division of Biochemistry and General Nutrition is at present overseas studying methods of assaying vitamin B12. He has visited Vienna, U.K. and U.S.A.

Tasmania

Dr. G. C. Wade, Chief Plant Pathologist in the Tasmanian Department of Agriculture, returned in November from a 16 month oversea trip under a Commonwealth Fund of New York Fellowship. While overseas, Dr. Wade has carried out research into biochemical aspects of brown rot in stone fruits at Berkeley, California, and Cornell, New York. In August, Dr. Wade began a tour of agricultural research institutions in England and the Continent before returning to Australia.

Professor H. N. Barber, Professor of Botany, in the University of Tasmania this year visited the U.S. and attended the recent Genetics Conference in Montreal, Canada.

Mr. G. T. Martin, Agronomist in the Tasmanian Department of Agriculture has selected a local ecotype of ryegrass which has produced crops throughout Tasmania which have been superior to crops grown from New Zealand seed. Stocks of seed are being built up for wider testing.

Mr. D. F. Paton, Senior Agronomist at the Mount Pleasant Laboratories, of the Tasmanian Department of Agriculture, attended A.N.Z.A.A.S. in Adelaide.

Mr. M. J. Fisher has been transferred from the Extension Service on King Island, to the Agronomy Division of the Department of Agriculture. He is now an assistant agronomist at Mount Pleasant.

Branch Notes

Australian Capital Territory

The series of lectures on the theme "Australian Agriculture of the Future" have continued. The speaker in August was *Mr. W. A. Gunn* who presented the producer's viewpoint on what trends he felt future Australian agriculture would take.

We wandered a little off agriculture to welcome here *Dr. Humphrey*, Chief of the Fisheries Division of C.S.I.R.O., who gave a talk on the future of Australian fisheries. As stated before these lectures will all be presented in full at the end of the series.

The Branch hopes to organise a social function, most probably a dinner, in the near future. Also a General Meeting is being held to discuss Institute affairs, particularly some of the implications of the President's last letter.

New South Wales

A joint symposium on "Water", arranged by the Branch and the "Men of the Land" Society, was held in October. This symposium was as successful as "Drought Mitigation" held last year.

Major items dealt with in committee were the final draft of Dr. Williams' report on employment of Agriculture graduates and a report by a subcommittee, convened by Mr. Ian Beale, on the "Question of Affiliation of Kindred Specialist Societies with the Institute". The general view was that the Institute had already "missed the bus" in not catering for specialist interests and that there was very little that could be done to attract kindred societies into more than a very loose affiliation; however every attempt should be made in the future to form specialist groups within the Institute.

Also under discussion was the possibility of establishing a sub-branch in the Southern area where some 70 graduates reside; the sub-branch would be centred at Wagga.

No activity was reported from the New England sub-branch.

Victoria

Professor C. M. Donald addressed a well attended meeting on aspects of agriculture in the Argentine. A series of colour slides gave added interest to the evening.

The Annual Dinner was held, as is customary, during Show Week, the date being September 23rd. The guest speaker was Mr. Andrew Garran, Chairman of the Public Service Board of Victoria.

The annual garden party to welcome new graduates was held on December 12 in the grounds of the School of Agriculture, University of Melbourne.

During October members were asked to comment on the proposal to form a Grassland Society. A very favourable response was obtained, from which it appears that such a society would have a large and enthusiastic united membership.

South Australia

All members of the Branch were pleased to learn of the election of three South Australians as foundation Fellows of the A.I.A.S. We congratulate *Dr. Cornish, Dr. Callaghan* and *Professor Prescott* on this high award.

The Branch committee has formed a programme sub-committee consisting of *Mr. H. P. C. Trumble, Dr. T. J. Marshall, Mr. G. R. Edwards* and the President Elect to develop a policy for future meetings and to arrange for speakers.

Recent meetings held were:—

September 26—*Dr. A. R. Callaghan*, Director of the S.A. Department of Agriculture, gave an address on "The Whole Farm Approach in Agriculture Advisory Work". This meeting was made open to the public and representatives of agricultural firms were invited.

October 31—*Dr. R. J. Swaby* of the Microbiological Section of C.S.I.R.O. Division of Soils, who returned from an overseas trip which included several weeks in the Soviet Union, spoke on "Aspects of Agricultural Research, Extension and Farming in Russia".

Queensland

Dr. B. R. Champ of the Department of Agriculture and Stock addressed the ordinary general meeting which was held on July 23. The speaker gave a detailed account of the many and varied uses which have been found for radioactive isotopes in entomology. The first part of his address dealt with the nature and assay of radioisotopes and Dr. Champ then went on to describe some interesting applications of isotopes in research.

At the August meeting *Dr. E. M. Hutton* gave an interesting lecture on "Breeding pasture plants for the tropics and sub-tropics". Dr. Hutton described the progress of the comprehensive plant breeding programme which he is carrying out at the Plant and Soils Laboratory in Brisbane and described the difficulties involved in producing a vigorous non-toxic pasture legume for the sub-tropics.

Mr. N. H. Shaw delivered his deferred Presidential address on "The management and utilization of native pastures in Queensland and southern Africa" at the September meeting. A number of systems of pasture management which are at present under study in the Union of South Africa and the Rhodesias were described by Mr. Shaw and contrasted with the practices followed in the Queensland beef industry.

Social Evening

A new type of social evening was held by the Queensland Branch on October 9 in the Compass Room at the Manhattan Hotel and from all reports was an unqualified success. Seventy-six members and guests attended and were entertained with a series of coloured transparencies shown by three members who have made overseas trips recently to places off the beaten track. Dr. Davies presented a picture of life and conditions in Baluchistan, a constituency of Pakistan which from all appearances is perpetually like our so-called desert after a protracted drought. Mr. Shaw then proceeded to travel through South Africa illustrating particularly the various influences on architecture and presenting evidence that the Victoria Falls are one of the wonders of the modern world. Finally Professor Herbert visited some out of the way places in Europe and gave everyone a yearning to see these places in the spring and summer time at least.

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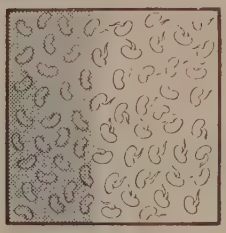

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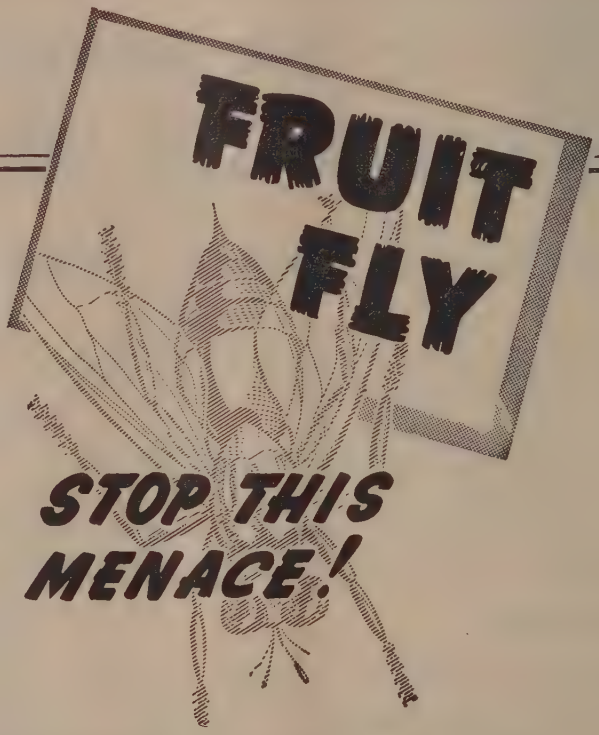

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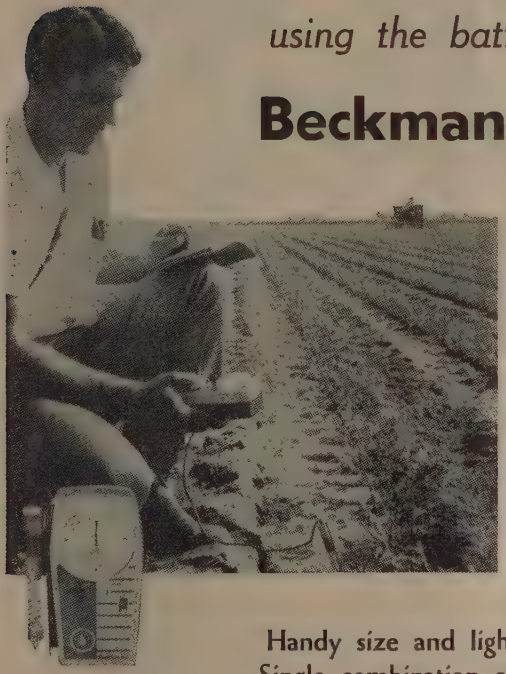

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COMMONWEALTH OF AUSTRALIA

Comonwealth Scientific and Industrial Research Organization

Division of Animal Health and Production

Applications are invited for appointment to the undermentioned positions with the Organization's Sheep Biology Laboratory located at Prospect, New South Wales.

According to qualifications and experience, commencing salary will be determined within the salary range of Experimental Officer Grade I, £966-£1,416 p.a. or Experimental Officer Grade II, £1,416-£1,686 p.a. Salary for a female appointee would be £170 p.a. less than the corresponding male rates.

Appointment will be conditional upon satisfactory medical examination and an initial probationary period of up to twelve months may also be specified. Confirmation of appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges.

Applications quoting the appropriate reference number and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should be forwarded to the Officer-in-Charge, Sheep Biology Laboratory, C.S.I.R.O., P.O. Box 144, Parramatta, New South Wales, by 31/12/58.

Appointment of Biological Chemist (*ref. no.* 205/161)

The appointee will be required to assist with the work of a research group which is investigating the endocrine control of wool growth.

Applicants should be graduates in Science or Agricultural Science, and have a good grounding in Biological Chemistry.

For appointment in the higher range of Experimental Officer Grade II the appointee would be expected to have considerable experience of one or more of

Commonwealth Scientific and Industrial Research Organization (Continued)

the following activities: (i) the fractionation and examination of protein mixtures; (ii) the analysis of adrenal cortical steroids in blood plasma by chromatographic methods; (iii) bio assay techniques; (iv) histological techniques; (v) the analysis of body fluids for various constituents.

The appointee in the lower range of Experimental Officer Grade I can expect to receive further in-service training in these specialties.

(Enquiries in connection with this appointment are most welcome and should be directed to Dr. K. A. Ferguson or Mr. J. H. Elliott at the above address. Sydney telephone number, YA 3721.)

Appointment of Biologist/Zoologist (*ref. no.* 205/164)

The appointee will be required to assist in the research programme of the Dermology Section. The work of the Section (using biochemical, physiological and histological techniques) is concerned with nutritional and physiological factors involved in wool production and with the development of the skin and of the follicle population of sheep.

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Appointment of Biologist/Physiologist (*ref. no.* 205/165)

The successful applicant will be required to assist with the experimental programme of a group studying the physiology of newborn lambs. This interesting work at present includes observations of neo-natal behaviour, calorimetry with the newborn lamb, and observations of physiological variables in both the pregnant ewe and her offspring.

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